Energy efficiency in buildings in China: Policies, barriers and opportunities

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Deutsches Institut für
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Energy Efficiency in Buildings in China

Policies, Barriers and Opportunities

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Tabea von Frieling
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Anja Minnaert
Nina Netzer
Jonas Rußbild

In collaboration with the Research Centre for Sustainable Development (RCSD) of the Chinese Academy of Social Sciences (CASS)

Energy efficiency in buildings in China

German Development Institute (DIE)

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Preface

We visited China just before the Olympics, which was a very impressive moment. The whole world was looking at and talking about China and we had the chance to actually see and experience the things that concern and amaze many people.

Our impression of Beijing was that the whole city is one big construction site: cranes and half-finished skyscrapers everywhere. The city was not only preparing for the Olympics, but also preparing for the developments China is facing in the up-coming years. China is the world's largest construction market and it is estimated that half of the buildings built every year in the world are located in China. It was impressive to observe the pace China is taking on this path.

After having finished this report, it is time to thank the people who supported this project and the report. This report was prepared by Carmen Richerzhagen, Tabea von Frieling, Nils Hansen, Anja Minnaert, Nina Netzer, and Jonas Rußbild. The project was conducted within the postgraduate training course at the German Development Institute (DIE) from November 2007 to May 2008 and was, at the same time, the first joint research project of an intensifying and long-term cooperation between DIE and the Chinese Academy of Social Sciences (CASS). The research and the finalization of the report were only possible due to the fact that the German team was outstandingly supported by a Chinese team from the Research Centre for Sustainable Development (RCSD) of the CASS, lead by Dr. Ying Chen. We sincerely thank the Chinese team for their hospitality and overall support. They made our stay very special. They provided important background information and statistics, gave us organizational support, aided us in finding the right interview partners or translating the interviews, exchanged with us their ideas and knowledge and, most important, helped us to find our way in China.

Apart from CASS, the team received valuable support from the German Technical Cooperation (GTZ) office in Beijing, especially from Xu Zhiyong, who supported us in multiple ways and was more than willing to share his knowledge and his experiences with us.

Besides the CASS and the GTZ, many organizations and individuals supported the research in China but also in Germany. We would like to

thank all our interview partners, experts and colleagues that contributed to this study. Special thanks go to the participants of the workshop in Beijing on April 28, 2008, during which we presented and discussed the preliminary results of the research.

We hope that our results will be of use to the Chinese as well as international scientific community in the field of Energy Efficiency in Buildings (EEB) and we also hope that Chinese policy makers can benefit from our recommendations in order to overcome existing structural and behavioral barriers. Last but not least, we think that the results are relevant for international cooperation and can be a signpost to a new path wherein EEB plays a greater role.

Carmen Richerzhagen   Bonn, December 2008

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Abbreviations

ACS	Air Conditioners
AQSIQ	State General Administration for Quality Supervision and the Inspection and Quarantine
BOCOG	Beijing Organization Committee for the Games of the XXIX Olympiad
BMU	Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMZ	Federal Ministry for Economic Cooperation and Development
CASS	Chinese Academy of Social Sciences
CDM	Clean Development Mechanism
CECP	China Energy Conservation Program
CEEB	Center for Energy Efficiency
CERs	Certified Emission Reductions
COP	Coefficient of Performance
Dena	German Energy Agency (Deutsche Energie Agentur)
DIE	German Development Institute (Deutsches Institut für Entwicklungspolitik)
EEB	Energy Efficiency in Buildings
ESCO	Energy Service Company
ETICS	External Thermal Insulation Composite Systems
GDP	Gross Domestic Product
GTZ	German Technical Cooperation (Deutsche Gesellschaft für Technische Zusammenarbeit)
GVB	Global Village of Beijing
HVAC	Heating, Ventilation and Air Conditioning

IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JUCCCE	Joint U.S.-China Cooperation on Clean Energy
LEED	Leadership in Energy and Environmental Design
mb/d	Millions of barrel per day
MoC	Ministry of Construction
MoF	Ministry of Finance
MOHURD	Ministry of Housing and Urban-Rural Development
NGOs	Non-governmental organizations
NDRC	National Development and Reform Commission
OECD	Organisation for Economic Cooperation and Development
RCSD	Research Centre for Sustainable Development
RMB	Renminbi (Chinese currency)
sqm	square meter
USGBC	U.S. Green Building Council
WBCSD	World Business Council for Sustainable Development
WWF	World Wide Fund for Nature

Summary

Global climate change is one of the most pressing challenges that the international community is facing today. While China is already feeling the negative effects of climate change, its heavy reliance on coal in order to satisfy the rising energy demands that are required for its booming economy has made the country one of the biggest emitters of greenhouse gases.

The Chinese construction sector substantially contributes to the country's CO_2 emissions. At present, about half of the floor space built worldwide is being built in China. Construction itself and the operation of buildings, i.e. heating and cooling within the residential sector, represent almost one third of China's total energy consumption. As urbanization in China continues unabated and living standards rise further, energy consumption in the residential building sector is expected to keep increasing as well.

Chinese policy makers have realized that enhancing energy efficiency in buildings (EEB) is a promising approach with regard to combining further economic growth with increased energy supply security and reduced local air pollution, amongst other benefits. Therefore, they have enacted a wide range of policies to foster energy efficiency within the building sector. While the policies can theoretically unfold a great energy saving potential, their implementation has been weak so far. This is where this study starts delving into the matter. It looks behind the scene of EEB in China, provides an overview on the existing policies and measures in place in order to promote EEB and identifies promoting factors as well as barriers for the implementation of EEB policies. Finally, it comes up with recommendations on how to overcome these barriers. Since the building sector is very broad, the study focuses on the heating and cooling issues of new and existing urban residential buildings in two important climate zones (i.e. the cold zone as well as the hot summer and the cold winter zone). They have the highest share of energy consumption and are regarded as being very pressing problems.

EEB in China: background information

China is foreseen to become soon the world's largest energy consumer and the largest emitter of CO_2 emissions. Some assessments even indicate that China is already the largest emitter due to its economic development. The

rapid increase in production and consumption of energy has taken place since market reforms were introduced in the late 1970s. The following rapid industrialization and urbanization of the country has triggered a high demand for energy, both to feed growing industry and business and to meet growing consumer demand, not only in China.

Looking at it from a national perspective, rising household income and population growth have significantly pushed up domestic demand in the residential sector, i.e. demand for real estate as well as electric appliances. According to the International Energy Agency (IEA), the residential building sector today accounts for 30 percent of the total final energy consumption and it is expected that the energy consumption of this sector will rise by 1.1 percent every year. However, one has to consider that per capita consumption of energy in China remains less than 30 percent of the average of countries which are members of the Organisation for Economic Cooperation and Development (OECD).

The current construction boom in China intensifies the energy utilization of the residential building sector. China is experiencing an unprecedented construction boom with 2 billion square meters being added to the current building stock of 45 billion square meters annually. At the same time, huge numbers of houses are demolished and replaced by new ones – the life-cycle of buildings in China is extremely short compared with that of buildings in industrialized countries. From 1990 to 2002, the annual growth rate of the building area was as high as 15.5 percent, making the building sector one of the most dynamic sectors of the country's economy.

In general, China uses vast amounts of energy in many sectors but even more parlous, the utilization is not efficient. China still has one of the highest energy intensities in the world. Although progress has been made since the 1980s, on average the country's ratio of energy consumption per unit of Gross Domestic Product (GDP) is relatively high when compared to other countries. Therefore, energy efficiency is a key that can allow low carbon development in China. Enhancing energy efficiency in buildings (EEB) is a promising approach to combine further economic growth and development with other positive side effects or benefits.

The major global benefit of enhancing EEB is its potential to mitigate climate change. At this stage, energy consumption in China has been directly linked to CO_2 emissions as the energy production portfolio is heavily dependent on coal and other fossil fuels. If China succeeds in reducing its energy consumption, CO_2 emissions will be reduced accordingly. Other positive side effects and so-called co-benefits of enhancing EEB are energy supply security, improved health and comfort, social welfare and economic stimulus. All these co-benefits are strong reasons for the Chinese government to take action on EEB issues, albeit supply security is the main driving force.

The construction sector is very dynamic and not only relevant in terms of energy consumption and emissions but also for the economy. The share of China's construction sector in its GDP is rising and investments, especially in real estate, have increased. The construction of new energy efficient buildings is important; however, large parts of the existing building stock need to be retrofitted as in the cold climate zone only one percent of the stock is energy efficient. Looking at the actor constellation and value chain of these two fields, it can be asserted that the value chain of new buildings is quite linear and clearly arranged whereas the value chain of retrofitting is complex and there is less experience at hand.

Plans, policies and instruments

In general, there is a strong political will to enhance energy efficiency in China. Many policies and measures have been enacted by the Chinese government that address energy efficiency issues. There are plans, policies and measures that determine the framework of EEB regulations. Until now there has been no law or regulation in place which concentrates exclusively on EEB. However, an important law touching the issue of EEB is the Energy Conservation Law which has been recently revised. Especially the EEB sections in the law have been strengthened determining penalties for non-compliance with EEB standards. It seems that EEB will receive more attention in the future. Recently, even a draft for a new regulation aiming especially at EEB was published which introduces new principles, guidelines and funding schemes.

Furthermore, there are instruments which implement the plans, policies and measures. They can be classified in i) command and control, ii) economic and iii) informational instruments. In the past, the Chinese government applied mainly command and control instruments in the building sector. Codes and standards, which regulate goals that buildings must reach as well as technologies that they must comply with, are the most used command and control measures in the case of EEB. There are national as well as regional standards and standards for public and commercial as well as residential buildings. However, the standards only refer to newly constructed buildings. There are no standards for existing buildings indicating a regulation gap.

Despite the domination of command and control instruments, in recent years, Chinese policy making has shifted towards market-based instruments and the government has diversified the instrument mix. Since 2007, economic instruments in the form of tax rebates and subsidies increasingly create economic incentives for EEB investment. For example, the government provides financial support for retrofitting or tax refunds for companies promoting EEB. According to the draft regulation for EEB, even more economic instruments will be established in the future, such as funds for the research on and development of standards.

The Chinese government has also initiated many information-related instruments. As in the case of economic instruments, it can be observed that such instruments are being increasingly applied. The instruments mainly used are labels, demonstration projects and campaigns. They all aim at improving the understanding and awareness of EEB. It was only in 2008 that the government introduced the Building Energy Efficiency Label, a mandatory label for government and large public buildings. Demonstration projects range from model cities to single demonstration buildings. Information campaigns are carried out as individual local activities rather than nationwide campaigns.

Factors influencing the implementation of EEB policies and measures in China

Five categories can be identified in which the determinants of successful EEB policy implementation crop up. The determinants arising in the fields legal environment and enforcement as well as economic parameters for investment can be clearly assigned to their categories whereas the informational and lifestyle factors are cross-cutting issues. The last category that analyzes the value chain is also cross-cutting but very actor-orientated.

i) Legal environment and the enforcement of EEB policies

The legal environment and the enforcement of EEB policies is the main factor affecting the implementation of EEB policies. The determinants take affect on the national and local level where the policy formulation and the actual implementation take place. Key players are first of all the central government, in form of the responsible ministry - the Ministry of Housing and Urban-Rural Development (MOHURD) - which develops the Chinese EEB strategies and second, the province and municipality governments that are responsible for implementing those strategies at the local level.

On the national level, the strong commitment by the central government to enhance EEB, i.e. the introduction of new policies and instruments as well as the abolishment of outdated policies, positively influences the implementation. In addition to policy enhancement, the government has also improved the institutional setting and has established new institutions, e.g. the China Green Building Council. It is responsible for administering the country's new green building labeling system which monitors the compliance with building standards and is used for enhancing public awareness. However, a single institution in charge of coordinating energy policy at the national level is lacking.

The strong commitment is mainly undermined by the weak monitoring mechanisms in place and the insufficient legal enforcement. The compliance with energy efficiency standards in new buildings is very low due to a lack of human and financial resources that can not address the complex construction process and the existence as well as the proliferation of bribery. Officially there are penalties regulated in laws that can be applied when non-compliance is detected, but in practice they are hardly enforced due to the weak legal system. These problems lead to an unsound and incomplete monitoring as well as enforcement and create a culture of non-compliance. The government has started to override the deficiencies and address these problems, but the activities are still at the very start.

Even though the policies and standards are developed in Beijing, they need to be implemented at the local level. It is obvious that some cities have a stronger commitment when it comes to enhancing EEB than others. Local governments try to enhance their reputation regarding energy efficiency and stand out with their own EEB policies and measures. However, many cities lag behind. Provincial governments and construction divisions in the cities face the challenge of having to deal with the details and complexities that the realization of policies brings along. Especially smaller cities face difficulties when trying to implement EEB policies or measures.

Additionally, the vertical implementation structure imposes problems. The ministry is in charge of EEB policies at the national level and, at the municipality level, local building authorities or energy bureaus are responsible for implementing EEB policies and measures. On the one hand, they have to consider the general national EEB strategy. On the other hand, they are only bound to and paid by the provincial government. This results in the fact that the central ministry plays a weak role and that there is the danger of conflicting instructions for local building authorities.

Another problem one should mention is the insufficient financial and human resources. Some provinces and cities have no special management units for EEB and not enough human resources to carry out an effective monitoring. Due to financial constraints, local civil servants often do not obtain training and lack the capacity to interpret and implement laws.

The lack of financial and human resources is directly connected with the prioritization of economic interests when compared to environmental and energy-saving issues. For a long time local leaders have been assessed based on their economic performance, which includes the expansion of construction. Therefore, they intend to push economic development in their region and use resources for this goal.

ii) Economic parameters affecting investments in EEB

Apart from the political factors, economic factors have been an important determinant for not achieving energy efficiency within buildings in the past. Distorted pricing schemes for energy, high prices of EEB technologies, and limited access to capital for investment have been major barriers to EEB improvements. However, in the last couple of years, the Chinese economy has undergone rapid changes. Economic growth and market reforms have changed the economic framework conditions within the relevant markets and have created new opportunities as well as challenges for the implementation of EEB policies. Especially the privatization of home ownership is a powerful market-based lever for EEB investments as it offers the opportunity to use end-users' incentives for EEB investments. However, many structural problems such as subsidized energy prices, the welfare system of heat billing and metering, the intransparency of the market as well as the lack of awareness and capital still counteract the positive effect of private home ownership on EEB in China.

The incremental costs for new energy efficient buildings are quite low (five to seven percent) when compared with the entire investment costs of a new building, whereas retrofitting of existing buildings is a costly option since it includes serious changes. However, the costs for energy efficient buildings are often overestimated. Not only households, but key players in real estate and construction also misjudge the costs and benefits of energy efficient buildings and are therefore reluctant to invest. Energy efficient equipment such as energy efficient air conditioners is much more costly (with regard to the purchasing price) than standard options. Due to the low energy prices – although energy prices have been increased in recent years – and the existing welfare system of heat billing and metering, the payback time is quite long and the incentives to invest are too low.

The energy prices and the systems of heat billing and metering in Northern and Southern China differ and influence the investment decision of households in different ways. In Northern China the heat billing and metering system has established strong disincentives to invest in EEB since heat cannot be individually controlled, is not billed according to consumption and is, in many cases, subsidized. The Chinese government has started to reform the system. However, a large-scale change still has to take place. In Southern China, both the costs for cooling and the costs for heating have to be paid according to consumption. Even if the energy price is still subsidized to some extent, the price for heating and cooling in the South orientates itself on the market price.

Incentives to invest in EEB are quite low for developers operating in the mass market because it hardly plays a part in the buying decision of their clients. However, an increasing number of high-end developers are engaging in green building projects. They can obtain a competitive advantage and an increased profit margin from EEB investments since their clients have a growing interest in improved living quality and high-end technology.

In general, in the construction sector capital for investments in new energy efficient buildings is available. Building prices have increased steeply in the last few years and are being driven by more and more investments. However, so far the capital is being invested for buying larger, more modern homes and is not being invested in energy efficient homes. Another problem is that most financial institutions are not willing to finance small EEB projects on a household level due to high transaction costs, the slow amortization of investments and the insecurity of the investment.

The provision of state funding in order to promote energy efficiency in the building sector has increased significantly during the last few years in order to fill the gap. New economic instruments have been introduced to promote the development of the EEB market, such as tariff cuts for companies, subsidies for developers surpassing the standards and a funding program for retrofitting. Nevertheless, most economic instruments are still in the planning process.

iii) Information, knowledge and awareness

The public knowledge on EEB is poor. This leads to a lack of awareness of the possible impact of EEB on climate change and its co-benefits and to a low acceptance of EEB products among residents. Consumers are not aware that they can reduce their energy costs and improve their living comfort by living in an energy efficient building and using energy efficient appliances. The lack of awareness is closely related with the lack of knowledge of technical measures and options to enhance EEB. In China people face great difficulties to evaluate the quality of energy efficient buildings and appliances because EEB is often invisible (e.g. wall insulation) and residents lack the technical know-how to evaluate the quality of EEB products. Therefore, they are not willing to purchase them.

The dissemination of EEB-related information by non-governmental actors has increased but the available information is still by far not sufficient and specific enough to significantly influence peoples' behavior. The media is the most important actor for the dissemination of information and in providing knowledge about energy efficiency issues to the general public. Energy issues have become an important and increasingly covered issue in the Chinese media but EEB is still lagging far behind. This seems to be due to the lack of know-how by journalists when covering complex EEB issues and the low publicity effect of this issue.

Apart from the media, non-governmental organizations (NGOs) play an important role for the dissemination of information. Chinese NGOs have shifted their attention from traditional environmental issues to climate change and energy. Some NGOs have therefore introduced special working units on the topic. NGOs active in the field of EEB have played a prominent role in advocating energy saving behavior through public campaigns and have begun to make an impact on government policy and practice. Their activities mainly concentrate on awareness raising campaigns, policy advice and capacity building as well as demonstration projects. However, due to limited financial and human resources as well as institutional restrictions they can not fully exploit their potential.

Just within the last years, national and international companies have discovered the great potential inherent in the formation of a new market for energy efficient building solutions and technologies in China. However, companies still face constraints when entering the market such as the intransparency of the Chinese housing construction market, a lack of knowledge about their products among building professionals and, in general, lacking public knowledge and awareness which inhibits the demand for energy efficient building features. In response to those challenges, companies and business associations have actively engaged in the dissemination of information about EEB through demonstration projects, training and capacity building as well as awareness raising campaigns. By applying such information-related measures on EEB, they intend to better position international companies within the Chinese market and bring best practices plus EEB products to China.

iv) The impact of Chinese culture, lifestyle and behavior on EEB

The rapid economic growth of China in recent decades has considerably changed lifestyles of Chinese residents and has led to an overall increase in energy consumption. Private home ownership and the size of the apartment have become an economic status symbol and the demand for these indicators has increased. However, EEB plays almost no role. Especially the little experience of residents with living comfort and their relatively short-term planning horizon are reasons why people are already satisfied with the improved living they have achieved by moving into a new building.

Furthermore, due to the fact that people in Chinese urban areas have been used to an extensive system of social welfare provision, they still award a strong role to the state in taking care of housing and energy provision. Since energy is considered as being a social right of the citizens and the main responsibility for retrofitting is delegated to the state, individuals only take limited action with regard to EEB. This behavior is even reinforced by the dissemination of EEB issues through a primarily top-down approach.

Energy behavior consists of the decision to buy energy efficient appliances and the behavioral patterns that influence the use of energy. According to surveys, consumers in China show almost no preference for energy efficient buildings and choose apartments according to other indicators (e.g. price and location). The same applies to energy efficient air conditioners. Most air conditioners sold in China have the lowest energy efficiency levels. The behavior regarding energy use in China differs according to the climate regions as well as the heat billing and metering system. It is obvious that energy efficient measures are implemented when residents can directly benefit from the saving energy costs or enjoy higher/lower room temperatures in winter/summer.

v) The value chain of the Chinese housing sector

The Chinese housing sector faces challenges in two sub-sectors: new buildings and the retrofitting of old buildings. In the case of new buildings barriers along the relatively linear value chain exist that obstruct the effective functioning of it.

Three links between actors in the value chain of the construction of new buildings are critical. First, the relationship between the local governments and the developers forms the market. The local governments control the prices of land through sales and thereby the access of developers into the market. Only a few developers actually operate in the market, thus ensuring that they have a great market power and a close relationship with the government. Other actors, e.g. architects and contractors, fall behind. Second, the separation of architectural design into two actor groups, namely the architects and the design institutes, imposes enormous efficiency losses. Third, important actors (architects, developers, workers) lack know-how regarding the use and the application of EEB technologies. Adequate training measures are rarely available in the mass market. However, high-end developers and producers of high-tech material and appliances depend on the use of EEB technologies. Their products can only be sold if the quality is significantly higher compared to the mass market. Therefore, driven by the market, some concerned actors (e.g. developers, buildings material producers) have established training measures or quality management units to improve the skills of building professionals and the quality of the products.

In the case of old buildings, the value chain is less linear as there are no established and universally applied procedures for retrofitting. Several challenges arise from this value chain. First, an actor who can initiate the complex and protracted process has to be identified. Since it takes a very high degree of auto-organization, in most cases, not residents but local governments will be the driving force behind retrofitting. Second, as most apartments are individually owned, residents themselves can only renovate the portions belonging to them, so the external wall insulation, roof heat insulation and heating system renovation need to be organized collectively. Transaction costs are generally high due to the large number of people involved and a lot of advocacy work on the part of the local government as well as other supporters. Third, retrofitting is a time-consuming undertaking which brings with it a great amount of discomfort for residents. Fourth, retrofitting old buildings is expensive compared with enhancing energy efficiency in new buildings. In most cases, the inhabitants of apartments in need of retrofitting are unable to pay for the whole cost of retrofitting or are not willing to carry the whole burden of improving the apartments which were originally constructed by the government.

Recommendations

The determinants for the implementation of EEB policies are identified in the areas of the legal system and enforcement, economic parameters for investment, awareness and lifestyles as well as the specifics of the value chain of the construction sector. Therefore, the recommendations apply directly to these fields.

Existing monitoring systems need to be improved and extended by increasing the quantity and quality of monitoring and integrating independent institutions. Apart from the improvement on the local level, national monitoring agencies need to be built up and cooperation between the local and national monitoring agencies has to be strengthened.

Economic incentives for EEB investments can be established on several levels. Most important are the adaptation of the energy prices to the prices on the world market and the reform of the heat billing and metering system. At the same time, it is also important to improve transparency within the market for EEB technologies. Certification and labeling systems are key instruments in increasing both transparency and public awareness. Funding of EEB investments is also a crucial issue. New and accessible funding schemes for EEB investments need to be introduced. New economic instruments such as tax cuts, subsidies and preferential loans for developers and households (i.e. micro credit schemes) to make EEB investments more attractive should be considered. Apart from traditional funding schemes, alternative sources such as Energy Service Companies (ESCOs), the Clean Development Mechanism (CDM) or the voluntary carbon market should be explored.

Awareness is essential and the precondition for investments in EEB and therefore a cross-cutting issue. Since distributed information and awareness of EEB are generally low, capacity building and awareness improvement is required for the range of actors that play a key role in informational management, i.e. governmental officials, journalists, NGO activists. Through workshops, forums as well as human and financial support, information can be shared, distributed and thereby increases awareness. Through directed campaigns preferences and buying-decision of consumers, being at the end of the value chain, can be influenced.

Finally, the links in the value chain need to be improved through the abolishment of split responsibilities, improving communication as well as technical know-how. Training is an essential measure in order to guarantee the effective application of EEB technology. Therefore, the government should create incentives for construction companies and architects so that they can avail of training for their employees and themselves.
In addition, also when addressing new buildings, national and local governments as well as international cooperation agencies should promote

the retrofitting of existing buildings in order to create the basis for the implementation of the heat billing and metering system reform. By means of a participative communication process, adequate solutions for sharing the costs of retrofitting need to be found. Therefore, best practices need to be transferred throughout the country via major platforms or other means of experience and knowledge.

1 Introduction

The mitigation of climate change, which is only possible if the dramatic increase in global greenhouse gas emissions can be stalled, is currently one of the most discussed challenges in international politics. The United Nations Climate Change Conference in Bali in December 2007 ended with all participants acknowledging the urgency of global action against climate change. In the Bali Action Plan, developing countries such as China agreed to consider "nationally appropriate mitigation actions" (UNCCC 2007). As these nations were not subject to any obligation in the Kyoto protocol to reduce greenhouse gas emissions, this initiative is of outmost importance.

China's impact on climate change is obvious: the country needs large amounts of energy to sustain its high economic growth rates. Due to China's heavy reliance on coal as a source of energy, this growth results in ever rising CO_2 emissions, which will make China become the world's largest emitter in the near future (IEA 2007b, 313). Some assessments even indicate that China is already the world's number one emitter. Not only has growth itself produced greenhouse gas emissions. It has caused a greater demand for electric appliances and living space, given rise to an intra-country migration flow from the poorer rural areas to the wealthier urban areas and brought about an unprecedented construction boom in the cities located on the Chinese east coast. Every year, two billion square meters are constructed; about 50 percent of the floor space built worldwide. Construction itself, but to an even larger extent the operation of the already existing and new buildings, consumes huge amounts of energy. Therefore, the building sector is an important part of the challenge to mitigate climate change in China. The question remains as to how China can take action. The urbanization trend and the use of energy cannot easily be reversed without threatening China's economic performance. However, China's utilization of energy is not efficient. The country's ratio of energy consumption per unit of GDP is relatively high compared to other countries. Therefore, energy efficiency is one key which will allow for low carbon development in China. Enhancing energy efficiency in buildings (EEB) is a promising approach in order to combine further economic growth with the emission reductions necessary to mitigate climate change.

In the authors' view, the main benefit of EEB is the reduction of CO_2 and SO_2 emissions which are pivotal in mitigating climate change and reducing the severe impact of acid rain, respectively. Climate change and acid rain, though, are not necessarily the most urgent national challenges that the Chinese government faces. Raising EEB has at least four co-benefits that makes this topic also interesting in the very short run when looking at it from the Chinese perspective: (1) enhanced energy supply security; (2) reduction of local, regional and indoor air pollution and therefore improved health, quality of life and comfort; (3) improved social welfare; and (4) an economic stimulus leading to employment creation and new business opportunities (IPCC 2007, 389).

In response to the current energy debate in China, the Chinese government decided upon ambitious targets in order to reduce energy consumption and diversify the energy mix. These targets were declared in the 10th and 11th Five-Year Plans and within many sectoral initiatives. In the building sector the targets are codified in numerous laws, codes and building standards. The design of policies and measures, however, varies largely between the different climate zones. China has five such climate zones, ranging from the "extremely cold" in the north, where heating is legally stipulated, to "hot summers and warm winters", where policies to regulate cooling activities are more suitable.

A World Bank study shows that the existing policies regarding the building sector have the potential to enhance energy efficiency by 50 percent compared to average efficiency rates in the early 1980s (World Bank 2001, vi). While Chinese policies are largely perceived as being of an advanced standard, their implementation has been weak so far.

Up to now, there is no comprehensive study on the implementation of energy efficiency policies in the Chinese residential housing sector, nor does an overview of existing policies and actors in this field exist. Research has rather focused on certain instruments such as national and regional standards (Wang et al. 2004; Huang et al. 2003) or emphasized the technical potential of certain technologies in order to enhance EEB (Lo / Zhao / Cheng 2006; Gu 2007; Hogan et al. 2001). This study aims to fill this gap. It first depicts the existing plans, policies and instruments. Thereafter, it analyzes their implementation with the aid of policy analysis. In this context, it identifies supporting factors and existing barriers for the implementation and, finally, comes up with recommendations to promote supporting factors and to overcome these barriers.

The purpose of the research is not to assess whether these measures themselves are sufficient, but to explain why the implementation has been weak so far. Therefore, the research question is:

Which factors influence the implementation of measures and policies to enhance energy efficiency in China's residential housing sector?

Although our basic assumption is that the policies and measures enacted by the central government would improve energy efficiency in buildings substantially if they were fully implemented, it is obvious that the legal framework itself is inappropriate in some areas. Firstly, the energy efficiency standards and norms new buildings have to comply with are not detailed and not sufficiently concrete. Therefore, it is hard to implement them. Besides, some standards are outdated and not of the same value as European EEB standards. Secondly, measures taken by the central government are too short-sighted, conflict-laden and just take action in one area. One example is the replacement of coal heating with electric heating in traditional buildings (*hutongs*) in Beijing, which reduces local air pollution but increases the inefficient use of energy. However, the implementation of the existing policies and measures would already improve the factual energy consumption in the building sector and mitigate CO_2 emissions. Therefore, we abide by this assumption.

The report is outlined as follows: Chapter 2 explains our research approach and the analytical framework which we employed. In chapter 3, we provide detailed background information on China's energy situation and its emissions, the importance of EEB enhancement in China, an overview of heating and cooling in China's different climate zones and of the set-up of the Chinese residential housing sector. Chapter 4 includes a mapping of the plans, policies and instruments directed at enhancing EEB in China. Chapter 5 constitutes the centerpiece of this report as it includes the results of our research. It is divided into five sub-chapters which deal with our findings in the fields of the legal system and its enforcement (5.1), economic parameters effecting investments in EEB (5.2), information, knowledge and awareness (5.3), the impact of Chinese lifestyle, culture and behavior on EEB (5.4), and the specifics of the Chinese residential housing sector (5.5). In chapter 6, we develop recommendations based on these findings. Finally, the annex explains the most important technical terms used in this report.

2 Case selection, research approach and analytical framework

The following chapter deals with the research focus and how we proceeded in order to answer our research question. It consists of three main parts: the first part, case selection, lists the research categories we used when selecting our cases. The second part outlines the approach we chose to collect the data and the third part explains the analytical framework of the research.

2.1 Case selection

We analyzed residential buildings within urban areas in the hot summer and cold winter climate zone as well as in the cold climate zone. The case selection is derived from the research categories. Five different research categories have been identified as significant: i) climate zone; ii) living area; iii) life cycle of buildings; iv) energy use; v) building type. Within these research categories, the cases selected were those that are most relevant for the case of EEB (see the annex for a detailed overview).

Firstly, the study focuses on two different climate zones that represent the two heating and cooling systems in place: the **cold climate zone**, where a central heating system is provided and electric appliances (e.g. air conditioners) are used for cooling, and the **hot summer and cold winter climate zone**, where electric appliances are used for heating and cooling. In the cold climate zone we visited projects and buildings and interviewed people in Beijing and Tangshan, in the hot summer cold winter zone we visited projects and buildings and interviewed people in Shanghai, having in mind that Beijing and Shanghai are special cases due to their economic and political strength. Beijing is China's capital, home to top government and educational organizations and is generally regarded as culturally and politically conservative. Shanghai has traditionally been China's most outward-looking city and has a long history of international trade and commerce. It is China's wealthiest city and the economic center of the "Golden Delta" region of the Lower Yangzi Valley (Brockett et al. 2002, 31). The cities' specifics need to be considered when transferring experiences and results to other cities.

Secondly, we decided to focus only on **urban areas** as their share of energy consumption when compared to rural areas is 80 percent (Chen 2008). This large share is due to rapid urbanization, a considerable building boom in urban areas and an increasing demand for better living quality. This trend will be forced even more in the future.

Thirdly, this study concentrates on the running of **buildings in the operation phase** and ignores other phases such as the manufacturing of building materials or the demolition of buildings. The operation phase makes up 80 percent of overall energy consumption (Chen 2008).

Fourthly, in the operation phase the study focuses on **heating and cooling** and excludes, for example, electric appliances used for other purposes such as television or refrigerator. Heating and cooling make up the highest share of energy consumption; they total 80 percent of the options as to how energy is used (Chen 2008).

Fourthly, regarding the building type, the study analyzes **new and existing buildings** whilst focusing on **residential buildings** and excluding commercial or public buildings. In the regions where central heating is provided (urban areas in the cold and extremely cold zones), residential consumption makes up 2/3 compared to commercial buildings with 1/3. In other areas their share is equal.

2.2 Research approach

At first, we conducted a preliminary desk study based on the analysis of primary and secondary literature mainly published in English. Literature on policy analysis and actor theory as well as EEB specific studies served to develop an analytical framework whose categories were used to explain the empirical data. Studies on EEB in general and, in particular, within China provided the information for a first mapping of policies, instruments, actors and determinants for the implementation of EEB policies and measures in China as well as furthering the development of preliminary hypotheses.

The corpus of information was gathered by 87 qualitative, semi-structured interviews during a three month field research phase (February to May 2008) in China. We collected information from seven relevant actor groups: government institutions (8 interviews), academic experts (14 interviews), companies (20 interviews), NGOs and the media (6 interviews), building professionals (9 interviews), households (16 interviews) and international cooperation (11 interviews) as well as 3 others[1]. For an exact overview of organizations and companies interviewed please see the annex.

We conducted two main types of semi-structured guided interviews: expert (71) and household (16) interviews. In addition, we gathered information through informal inquiries and participatory observance. The expert interviews are especially suited for the collection of factual data and to gain information on the specific perceptions of different types of actors involved in the implementation of EEB policies within China. The household interviews were not intended to deliver a representative sample of Chinese households. Rather, they helped the authors to get a more complete picture as well as a bottom-up perspective. The information gained through household interviews served as control samples in order to validate the data of the expert interviews. Furthermore, the household interviews were an important tool in order to gain an impression of the living space and habits of ordinary Chinese residents (participatory observation).

We collected two types of data:

1) Factual data on existing policies and measures, instruments and the procedures involved for the implementation of EEB policies in China as well as data on the involvement and share of different actors for the implementation of EEB policies in China. The data was collected through the analysis of already existing studies and through interviews with relevant actors.

2) Opinions, judgments and narratives concerning the awareness of EEB and the implementation of EEB policies in China from the perspectives of different actors. The data contributes to a deeper

1 One environmental lawyer, one interpreter and one marketing director of a carbon-neutral hotel.

understanding of specific experiences and perceptions of different actors of the topic and was collected through interviews with different groups of relevant actors.

We structured and analyzed the data with recourse to the categories of analysis from our analytical framework. To increase the validity of the data, which was collected through the interviews, we applied various methods of data triangulation such as the comparison of statements on the same issues in interviews with different interview partners or the discussion of the interviews within the teams of interviewers as well as within the whole research team.

Constrains to data collection

We faced two main challenges regarding our interviews: a lack of Chinese language skills and a lack of personal contacts. The language barrier was a problem during the conducting of interviews and with regard to the interpretation of interviews as well as with regard to the accessibility of information. For the identification of and appointments with interview partners, especially from Chinese government agencies and households, the German research team depended to a large extent on its Chinese partner.

2.3 Analytical framework

The successful or failed implementation of EEB policies and measures cannot be explained by referring to only one factor such as the actions of a certain actor group or the institutional setting of the construction sector. Since *"it is not only the kind of action, but also its structural conditions which matter"* (Jänicke 2002, 3), we chose a holistic, multi-factorial approach that takes into account both structural determinants as well as actors in order to analyze the implementation of EEB policies in China.

According to Jänicke (Jänicke 2002), the successful implementation of environmental policies is influenced by the complex interaction of a variety of factors: the interaction and behavior of different groups of actors, the short-term conditions of action that can alter the behavior of actors as well as structural political-institutional, informational, economic and technological determinants. These factors are embedded in and influenced by changes within the international context. However, the suggested categories are not directly applicable to the case of EEB. They are too broad and unspecific for the explanation of the implementation of EEB policies. Therefore, based on the existing analytical framework developed by Jänicke and a literature review on EEB, we developed a new analytical framework, identifying structural categories that impact the implementation of EEB policies. We identified supporting factors and barriers of the implementation of EEB policies as well as measures within the categories.

Apart from the structural categories, actors are very relevant for policy implementation. Policy outcomes are determined by the interaction of individual and collective societal actors, each with their respective interests, power resources and strategies (Jänicke 2002, 5). We took into account the strong role of actors for the implementation of policies and integrated them in our analytical framework. We identified the most relevant actors in the EEB policy field and analyzed their capacities and the way they interact. We identified six important types of actors: (1) government institutions; (2) non-governmental organizations and (3) the media; (4) companies; (5) building professionals and (6) households.

We identified five relevant categories in which determinants in the form of supporting factors and barriers can be identified:

1) Legal environment and enforcement

2) Economic factors affecting the investment

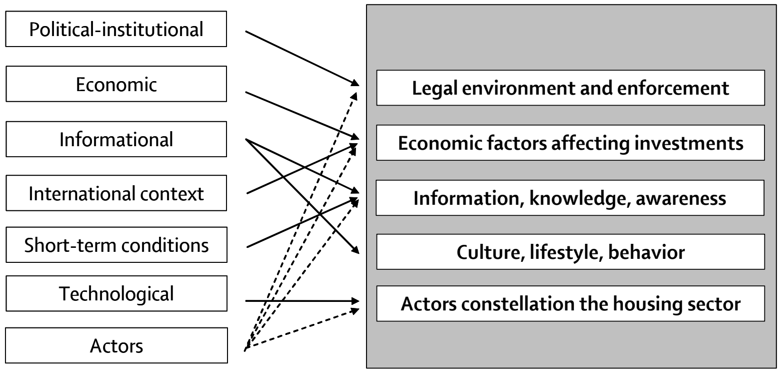
3) Information, knowledge, awareness

4) Culture, lifestyle, behavior

5) Actors constellation within the housing sector

Structurally, the two categories legal environment/ enforcement and the economic factors affecting investments are obviously the most influential categories and harbor the strongest factors impacting the implementation. However, informational deficits, cultural specifications and the actors' constellation are important cross-cutting categories that intensify the shape of the others.

Figure 1: Development of the analytical framework



Source: Own design

3 EEB in China: background information

Why is EEB relevant for China and who is concerned and involved? This chapter provides background information on the energy and greenhouse gas emission situation in China (3.1), the importance of EEB in China (3.2), the heating and cooling systems in the different climate zones in China (3.3), and the actors that are the most relevant for the implementation of EEB policies and measures within the Chinese housing sector and their constellation (3.4).

3.1 Energy and emissions in China

The energy sector in China is growing rapidly. Economic development, industrialization, urbanization and improved quality of life are impelling an energy demand that is growing much faster than in other parts of the world.

Demand and supply of energy

China is foreseen to become the world's largest energy consumer after 2010 (IEA 2007b, 283), overtaking the United States. Currently China ranks as the second largest energy consumer and producer in the world. The rapid increase in production and consumption of energy has taken place since market reforms were introduced in the late 1970s and 1980s. The following rapid industrialization and urbanization of the country has triggered a high demand for energy, both to feed growing industries and businesses as well as to meet growing consumer demand (Austin 2005, VII).

China still has one of the highest energy intensities in the world. Although progress has been made since the 1990s, on average China needs more than three or four times as much energy input per unit of output as developed economies (ASRIA 2003, 9). However, per capita consumption of energy remains less than 30 percent of the average of OECD countries (IEA 2007b, 265).

Driving forces for energy demand in China are in particular the industrialization, international trade (i.e. increasing export of manufactured goods) and the growing domestic demand. With 42 percent of total final energy consumption, industry is still the largest end user of energy (IEA 2007b, 292). However, rising household incomes and population growth have pushed up domestic demand in the residential sector (real estate as well as electric appliances) and for transport.

The speed of the economic growth has led to temporary power shortages across the country. Households and businesses had to experience planned power outages on a regular basis. The mismatch between demand and supply was particularly severe in the summers of 2003 and 2004, when higher than expected industrial growth, combined with a surge in the numbers of air conditioners, led to shortfalls in power supply in large parts of the country. The Chinese government has reacted to the shortfall by raising the countries installed generation capacity by 105 GW in 2006 alone – starting at 517 GW installed until 2005 this accounts for a rise of some 20 percent (IEA 2007b, 343). Such a rise in generation capacity is without precedent anywhere. In consequence, energy supply and demand are evening out. However, some areas continue to suffer periodic shortages (IEA 2007b, 266).

The Chinese primary energy mix is dominated by coal. About 68 percent of the fuel consumption is coal-based generation. In comparison, coal accounts only for 12.1 percent and 5 percent respectively in the US and in the OECD as a whole. Such heavy reliance on coal carries high costs, since its use in electricity production is one of the main sources of air pollutants and of greenhouse gases, such as CO_2 (Austin 2005, 6). In consequence, the Chinese government plans to increase the use of nuclear, hydro and other renewable energies in order to reduce its reliance on coal and oil. In 2005 the government passed the Renewable Energy Law which aims to boost China's renewable energy capacity to 15 percent by the year 2020 and outlines a commitment to invest $180 billion in renewable energy over this period (Li 2006).

China's energy emissions

Currently China is the biggest emitter of SO_2 in the world. China's SO_2 emissions, the major cause of acid rain, are projected to increase even further from 26Mt in 2005 to 31 Mt in 2015, before leveling off to 30 Mt by 2030. China's energy-related CO_2 emissions will soon exceed those of the US, making it the world's largest emitter. However, China's per-capita emissions remain much lower than those of the US, not even reaching current average OECD levels (IEA 2007b, 283). The projected rise in energy demand has major implications for the local as well as global environment (IEA 2007b, 283). As many countries in the world, China will also be affected by climate change, e.g. by temperature increases and a sea level rise in the coastal areas.

3.2 The role of energy efficiency in buildings

The role of residential buildings in the context of climate change is twofold: on the one hand, energy efficient buildings protect their inhabitants against the effects of climate change, e.g. hotter temperatures. On the other hand, residential buildings themselves contribute to the emission of greenhouse gases (Civic Exchange / Architects Association of Macau 2008, 4).

The Chinese residential building sector accounts for approximately 30 percent of the country's final energy consumption. It is expected that energy consumption of the residential sector will rise by 1.1 percent every year (IEA 2007b, 265/304). As a result of China's high economic growth rates and continuous urbanization, China is experiencing an unprecedented construction boom. At the same time, huge numbers of houses are being demolished and are being replaced by new ones – the life-cycle of buildings in China is extremely short compared with that of buildings in industrialized countries. From 1990 to 2002, the annual growth rate of the building sector was as high as 15.5 percent, making this industry one of the most dynamic sectors of the country's economy (Kang / Wei 2005, 281).

Residential buildings in China are estimated to consume between 50 to 100 percent more energy for space heating than buildings in similar cold climates in Europe or North America, while still offering far less comfort (World Bank 2001, 1). The Intergovernmental Panel on Climate Change (IPCC) showed that by reducing the energy intensity of buildings' operation, up to 29 percent of this energy can be saved at virtually no cost (IPCC 2007). Accordingly, China's potential to reduce energy consumption through enhancing EEB is enormous.

The major global benefit of enhancing EEB is its potential to mitigate climate change. By now, energy consumption in China has been directly linked to CO_2 emissions as the energy production portfolio is heavily dependent on coal and other fossil fuels. If China succeeds in reducing its energy consumption, CO_2 emissions will be reduced accordingly.

However, enhancing EEB means killing five birds with one stone: apart from reducing greenhouse gas emissions, there are four co-benefits that take effect at both a national and local level.

1) Supply security. Supply security is one of the most important challenges to the Chinese government. In 2006, China's net oil imports reached 3.5 mb/d – the third largest after the United States and Japan. During the past two years China has started to import liquefied natural gas and has become a net importer of coal for the first time ever (IEA 2007b, 261). Therefore, it stands to reason that the government fears shortages in energy supply in the future and rising energy prices on world markets. Increasing EEB will lower total energy consumption.

2) Health and comfort. Today, respiratory diseases due to poor air quality are the major cause of death in urban areas where approximately 70 percent of the Chinese population live (Wang et

al. 2004, 1306). In many northern cities, the air pollution index was two to five times above the upper limit set by the World Health Organization (WHO) (Kang / Wei 2005, 282). A "business-as-usual" scenario developed by the OECD predicts that health costs due to local air pollution are equivalent to 13 percent of GDP (IEA 2007b, 310). Promoting EEB can substantially improve indoor air quality as well. EEB results in less dependence of the indoor temperature on outdoor climatic conditions. A better insulation can reduce energy costs while making the indoor climate more comfortable.

3) Social welfare. EEB lowers energy bills. It contributes to increased social welfare and poverty reduction because it sets financial resources free which the poor up to now are forced to spend on energy. Additionally, energy efficient technology can make basic energy services accessible to those that have not been able to afford them in the past (IPCC 2007, 418). However, the costs for EEB technologies have to be paid.

4) Economic stimulus. Investments in EEB can create employment, both directly through creating new business opportunities and indirectly through the *"economic multiplier effects of spending the money saved on energy costs in other ways"* (IPCC 2007, 417).

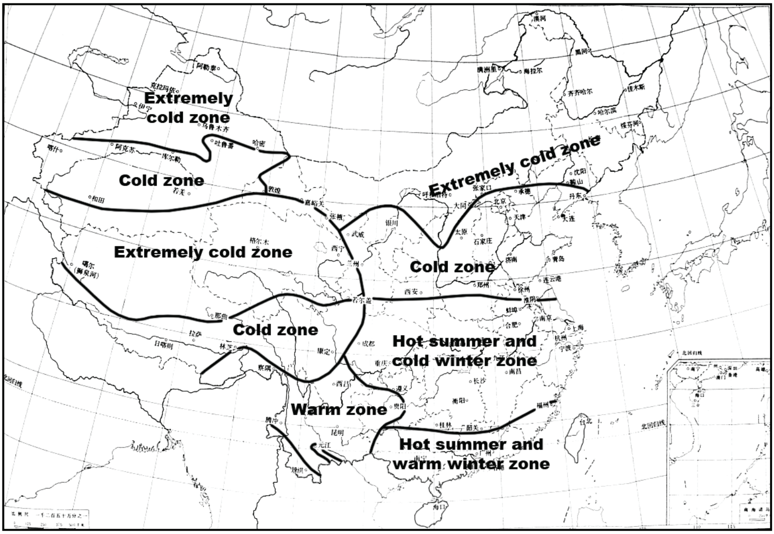
3.3 Heating and cooling in China's different climate zones

The Chinese government has classified China into five different climate zones according to the average temperature in the different regions: "extremely cold", "cold", "hot summer and cold winter", "hot summer and warm winter" and "warm". The heating and cooling systems vary according to the different climate zones (Figure 2).

Heating and cooling in Northern China

In the Northern climate zones ("extremely cold" and "cold zone") central heating is the dominant heating form in urban areas. More than 80 percent of all apartments in Beijing have access to coal-fired central heating. For

Figure 2: China's climate zones



Source: Thermal design code for residential buildings GB 50189-2005

example, in Urumqi almost 100 percent of the apartments are connected to the central heating system (Yoshino 2006, 1311). The remaining apartments are heated by individual heating systems. These heating systems use gas or electricity.

Costs for central heating are not calculated according to actual use, but rather according to the heated area by the floor size of the apartment. The price for central heating is capped at 24 RMB/m^2[2] for the heating period. Central heating is only available during the heating season independent of outdoor temperatures outside of the heating period. In Beijing central heating is operated from 15 November to 15 March (Yoshino 2006, 1310). Most buildings attached to central heating still have one-pipe heating systems where heat cannot be regulated individually. Only new buildings are equipped with the new system allowing individual regulation. Room temperature can often only be altered by opening and closing windows.

2 24 RMB equate to 2,75 Euro (November 2008).

Residents complain that, in consequence, apartments are often too cold or overheated, depending on the location of the apartment within a building (e.g. corner apartments cool quickly) and the outdoor temperature.

Many employers in Beijing, in particular government institutions, still cover costs for central heating as part of the monthly salary. Heating costs amount to about 15–30 percent of individual household incomes (World Bank 2001, 20). The employer either pays the heating bill directly or transfers a subsidy for heating to the employees.

Energy costs for the remaining individual heating systems are billed according to consumption. In general, they are more expensive than central heating, but they have the advantage that the room temperature can be regulated individually and that heating systems can be turned on before or after the heating periods as well.

Unlike heating, cooling is not provided centrally in Northern China. During the hot months, when average temperatures are between 25 and 30 °C, air conditioners are being increasingly used more and more. Electricity costs for cooling with air conditioners have to be paid directly by the households according to consumption (Duda / Zhang / Dong 2005, 533).

Heating and cooling in Southern China

Outside of the heating zone, heating is not provided by the state. The use of central heating systems south of the Yangtze river even used to be prohibited in the past, although temperatures in the “hot summer cold winter” region fall below 5 °C up to 90 days a year (Duda / Zhang / Dong 2005, 533). Originally, with this policy the central government aimed to save energy. However, households today are demanding an improved room climate. In consequence, most households in this climate zone use air conditioners not only for cooling, but for heating as well. This practice (i.e. using electricity to heat) is highly inefficient. As electricity costs have to be paid for according to consumption, residents have to pay the full price for heating and cooling themselves (World Bank 2001, 45). In China today, an average of 80 percent of urban households own an air conditioner. The ownership rate doubled every three years since 1990 (IEA 2007a, 308).

3.4 The Chinese housing sector

According to the World Energy Outlook (WEO) 2007, China is experiencing an unprecedented construction boom with 2 billion square meters of new buildings being added every year. Additionally, large parts of the existing building stock need to be retrofitted. These two sub-sectors represent different value chains concerning EEB investments. Whereas the value chain of new buildings is quite linear and clearly arranged, the value chain of retrofitting is complex. The following sub-chapter attempts to point out the factors arising from the value chain and the actors' constellation that impact the implementation of EEB policies.

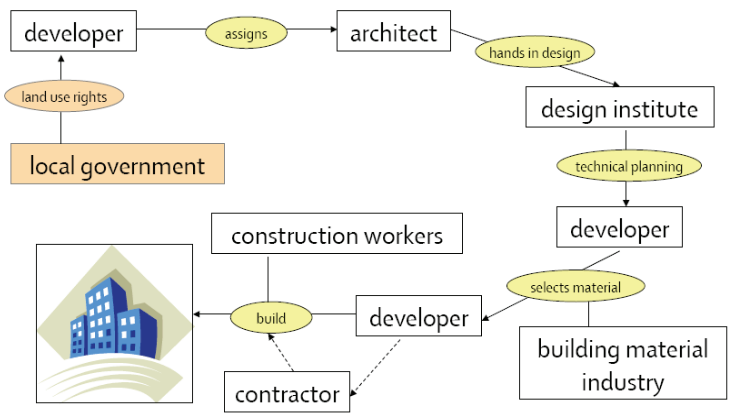
The Chinese construction sector

The World Bank predicts that by 2025 half of the world's building construction will take place in China (World Bank 2001, 3). Furthermore, it is expected that the urbanization rate will increase enormously. Urban residential living space already increased by 50 percent between 2000 and 2005 due to a growing population and the increased floor space per capita (IEA 2007b, 306). The construction sector is very relevant for China's GDP; its share has increased from 4.3 percent in 2000 to 7 percent in 2004. Investment in construction and installations rose by 208 percent during the same period. The fastest-growing area of capital spending has been real-estate investment, which has increased by over 20 percent every year since 2000 (The Economist Intelligence Unit 2006, 62/45).

The Chinese construction sector is characterized by a linear value chain and a relatively organized actor constellation (see Figure 3). The developers form the starting point of the value chain. They obtain land use rights from their respective local government. These land use rights are generally limited to 70 years all over China – afterwards they fall back to the government (Chen 2007, 18).

After having received the land use rights, the developer assigns an architect with the design of the building. To be allowed to work out the technical planning of a building, an architectural office needs a license issued by the *Ministry of Housing and Urban-Rural Development* (MOHURD). Architectural offices that dispose of this license – so-called design institutes – can work out the technical planning of their own buildings and of buildings that have been designed by other architects. The

Figure 3: Actor constellation in the Chinese housing sector



Source: Own design

final plan has to be cross-checked by a third party, usually another design institute, before being approved. When the plan is completed, the developer selects the building material and starts with the construction. Depending on their capacities some developers construct the building with their own company and some assign a contractor to carry out the construction.

Retrofitting of existing buildings

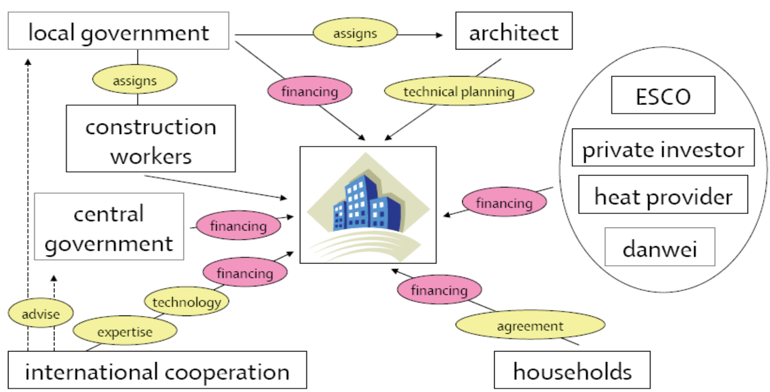
It is assumed that in new buildings great achievements have been made in improving EEB while in existing buildings a lot remains to be done. According to government officials, in the heating zone of Northern China, only one percent of the existing building stock is energy efficient (Chinagb.net 2008b). Therefore, retrofitting older buildings which hardly contain any thermal insulation and are still equipped with a one-pipe heating system has the potential of increasing energy efficiency substantially and thereby reducing CO_2 emissions. In Northern China, it would be worthwhile retrofitting 2.5bn square meter of existing residential buildings, representing a saving potential of 55 million tons of CO_2 emissions per annum (GTZ 2008, 15). To this end, it is necessary to install the following in older buildings: first, a two-pipe-heating-system, second, thermostats and, third, heat-meters to allow individual regulation, metering and billing (for technical explanations please see the annex). Additionally, the heat-provision systems need to be renovated so that they can deal with the expected high variations in demand.

Retrofitting creates the technical conditions for the full implementation of the heat billing and metering system reform and can build support for it amongst the residents themselves. Apartments in need of retrofitting are frequently inhabited by residents with few economic resources. Retrofitting can lead to lower heating bills, raise room temperatures, create a healthier living environment, increase the value of apartments and improve the overall quality of life for these lower income groups.

Compared to the construction of new buildings, retrofitting is much more complex (see Figure 4). The process of retrofitting usually begins with an initiative by the local municipal government. The government, which also partly finances retrofitting, contacts households to talk with them about the possibility of their buildings being retrofitted. Obtaining the residents' agreement to retrofitting and to financing a part of it usually constitutes a long and complex negotiation process. Here, international cooperation agencies can step in to moderate between the different parties and their interests. Furthermore, international co-operation agencies can offer financing, technical advice to both the central and local governments, access to advanced technology from abroad and lessons learnt from retrofitting projects in their respective countries.

Once a consensus has been reached, the local government can assign the work to an architect who works out a technical plan which serves as a blueprint for the work of construction workers who, too, will be assigned by the local government. With respect to financing, the central government also usually carries a part of the burden. In addition, sometimes an Energy Service Company (ESCO), a private investor, the local heat provider and the company which used to own the apartment (*danwei*) will contribute to financing retrofitting.

Figure 4: Actor constellation for retrofitting



Source: Own design

4 Plans, policies and instruments

Policy instruments make up the formal "rule of the game" to achieve EEB. They serve the government to overcome market failures which inhibit energy efficiency improvements. Barriers include unstable, distorted or incomplete prices, a lack of information, lifestyle and behavioral influences, and consumption patterns (IPCC 2007, Chapter 5).

In order to identify the promoting factors and the barriers of policy implementation it is necessary to have a look at the existing policies and instruments. The following chapter aims to map the plans, policies and laws (4.1) as well as the policy instruments that the Chinese government uses to enhance EEB. Policy instruments are classified as control and command (4.2), economic (4.3) and informational instruments (4.4).

The chapter shows that there is a strong political will to enhance energy efficiency in China. In the past, the Chinese government intended to achieve this goal in the building sector by using overall command and control instruments and demonstration projects. In recent years, Chinese policy making has shifted and the government has diversified the instrument mix. The Chinese government is increasingly making use of market instruments since 2007. New economic funding schemes such as tax rebates, subsidies and new informational instruments such as labeling systems have been introduced, which aim to create economic incentives for EEB investment and to improve market transparency.

4.1 Plans, policies and laws

The Chinese government has committed itself to ambitious targets to improve energy efficiency. In its 11th Five-Year Plan for National Economic and Social Development (2006-2010), the Chinese government set the target to decrease energy consumption per unit of GDP by 20 percent. However, the implementation is quite difficult and in the first year China had difficulties to reach the annual target of four percent (Richerzhagen / Scholz 2007, 8). Facing this situation, the central government has a strong interest to improve policy making for EEB and to remove barriers which inhibit existing policies to function. The housing construction sector is considered to be one part of the general energy strategy.

Several laws have been adopted to implement the targets. They create the legal framework for the enforcement of the efficient use of energy and the reduction of energy losses in buildings.

a) Energy Conservation Law of the People's Republic of China

The Energy Conservation Law came into effect on the 1st of January 1998. According to article 1, the law *"has been formulated with a view to facilitating energy savings* throughout *society, improving efficiency and economic benefits of energy use, protecting the environment, guaranteeing national economic and social development and meeting the needs of people's livelihood"*. The law says that every entity or individual has the obligation to save energy and the right to be informed about the waste of energy. Article 37 is directly linked to buildings when it says: *"Building designs and construction shall (...) employ energy-saving types of construction structures, materials, facilities and products, improve heat* *insulation properties and reduce energy consumption for space heating, cooling and lighting”*.

The law was revised in 2007. EEB is one key area in the amendment. EEB-relevant changes are, amongst others, the renaming of the Ministry of Construction (MoC) to Ministry of Housing and Urban-Rural Development (MOHURD) and the determination of penalties for non-compliance with EEB standards. It also explicitly provides that the fulfillment of energy conservation targets is taken into consideration when evaluating the performance of local government officials (Chinagb.net 2008b; Chinabg.net 2008a).

b) Renewable Energy Law of the People’s Republic of China

The Renewable Energy Law entered into effect in January 2006. It is related to the building sector only as far as solar energy and heat pumps are concerned. The law stipulates the connection of renewable energy sources to the grid and the integration of renewable energy in public buildings. According to the Renewable Energy Law, the MOHURD is obliged to develop technical standards for renewable energy technology such as solar water heaters and heat pumps. An important follow-up measure of the law is the creation of a Renewable Energy Development Fund by the Ministry of Finance (MoF), which took place in June 2006. As an example, this fund provides financial means to house owners to support the installation of renewable energy appliances (Baker & McKenzie et al. 2007).

c) Draft of EEB Regulation

Up to now, there was no law or regulation which was only concerned with EEB. Recently, a draft for a new regulation aiming especially at EEB has been published in addition to the overarching plans and laws. The draft is structured into six chapters, which contain principles and guidelines for new buildings, existing buildings, electric appliances, compliance with building standards and economic incentives. Important paragraphs state that demonstration projects and lower energy consuming buildings which go beyond the 65 percent standard[3] can enjoy a tax reduction. Furthermore, they state that in public buildings with an air conditioning system the temperature should be set above 26 degrees in summer and below 20 degrees in winter. The regulation also stipulates that the central and local governments should arrange specific funding in several areas (e.g. retrofitting, energy audit, etc.).

A guideline concerning retrofitting of existing buildings was issued in July 2006. It states that in the period of the 11th Five Year Plan from 2006 to 2010, large cities have to finish 35 percent of retrofitting, 25 percent is the quota for medium size cities and 15 percent for small towns.

d) Reform of the heat billing and metering system in Northern China

In 2003, the Ministry of Construction and seven other ministries jointly issued a guideline and decided to reform the existing heating system in Northern China. The Deputy Minister of Construction, Qiu Baoxing, called the reform the key to the central government's efforts to cut soaring energy consumption and turn China into a resource-saving and environment-friendly society. The reforms were expected to lead to 27 percent energy savings in the building sector and to create a substantial market for retrofits in order to improve building energy performance (Kang / Wei 2005, 297).

Box 1: Steps of the heat reform

The reform requires a lot of financial and technological resources. Therefore, it is planned to implement the reform in several steps. Steps 1 and 2 have been partly implemented in a few pilot cities and are now supposed to be expanded to all cities. These actions were supposed to be accompanied by a heat supply company reform. Central heating is supposed to be promoted further.

3 The central government has developed regulations for energy saving in buildings. They aim to save 50 percent energy in all new buildings and 65 percent energy in selected large municipalities: e.g. Beijing, Shanghai, Tianjin, and Chongqing.

Step 1: Households have to pay for their heating bill

Employers are relieved of the responsibility to pay for their workers' heating charges. Households are supposed to for pay the costs of heating directly to the heat providers. Instead of paying the heating costs, the government transfers subsidies to building residents. Less well-off urban residents are supposed to receive allowances from the government.

Step 2: Heating energy is metered

Energy consumption is no longer going to be metered on the basis of floor space, but on actual heating consumption, as it is already done in Southern China. To make heat metering possible, heat meters have to be installed. In 2003, the installation of heat meters became mandatory in new buildings. A subsidy program for retrofitting was launched by MOHURD in conjunction with the MoF to stimulate the installation of heat meters in existing buildings. In April 2008, the new Energy Conservation Law entered into effect. In article 38 the installation of heat meters for central heating is regulated.

Step 3: Heating is billed according to consumption

A proper and socially acceptable heat price is supposed to be formulated and a market-based mechanism for heating is supposed to be introduced.

4.2 Command and control instruments

Command and control instruments refer to government regulations that can be enforced through penalties. They are very popular instruments in environmental policy because it is believed that these achieve their objectives quicker and with greater certainty than economic instruments (Harrington / Morgenstern 2004, 13-17). However, they have higher administrative costs and often do not lead to innovation, since by setting a limit they do not encourage a performance level that is better than the limit sets down (Beerepoot 2007, 7).

Codes and standards in the case of EEB are the command and control measures, which are often used. Codes and standards regulate goals and technologies buildings must reach and comply with. They set energy-efficiency targets and often require the installation and use of specific types of equipment. In China, there are national as well as regional standards and standards for public and commercial as well as residential buildings. The standards only refer to newly constructed buildings; there are no standards for existing buildings.

a) National standards

According to the "Standard of Climatic Regionalization for Architecture" (GB 50178-93), China is divided into five climate zones: "extremely cold", "cold", "hot summer and cold winter", "hot summer and warm winter" and "warm". Starting in 1986, the Chinese government issued several standards referring to EEB in these different climate zones (Liang et al. 2007, 1098). These will be listed under b) regional standards. However, there are several national standards as well:

The "Thermal design code for public buildings" (GB 50189-2005) contains the target of a 50 percent reduction in heating, cooling ventilation, air conditioning and lighting energy. It was approved in 2005, and refers to newly constructed public and commercial buildings (Liang et al. 2007, 1102). A national standard for residential buildings has not yet been developed, but regional standards for residential buildings do exist (see b) regional standards). However, the 2007 National Standard for Residential Buildings, which aims to harmonize the current building standards, is under consideration (IEA 2007b, 383).

In March 2006, an evaluation standard for green buildings (GB/T 50378-2006) was published. The standard concerns all new buildings, building extensions and renovations (includes residential and public buildings). The evaluation should be undertaken in the first year of operation following the completion of the building. However, the standard is not compulsory, and is in its test phase. The evaluation consists of building performance monitoring and an economic evaluation throughout the whole life cycle. The main criteria for the evaluation are: land conservation and environmental protection, energy conservation and use, water conservation and use, materials conservation and resource use, indoor environmental quality and management (residential buildings) and life cycle performance (public buildings).

There are further specific standards and codes which prescribe technical requirements:

- Technical standard for outside isolation of outside walls (JGJ144-2004)
- Technical standard for performance assessment of residential buildings (GB/T50362-2005)
- Technical standard for the employment of solar water heater systems (GB50364-2005)
- Technical standard for the operation and management of air conditioning and ventilation systems (GB50365-2005)
- Technical standard for heat pump systems (GB50366-2005)
- Standard for the construction of residential buildings (GB50368-2005)

b) Regional standards

The above listed national standards apply to every region and climate zone in China. However, local governments can have their own standards and codes as long as they go beyond the national ones. One example is the 65 percent standard in Beijing and three other municipalities, which exceeds the national one of 50 percent (energy-saving design standard for the heating of residential buildings DBJ 01-602-2004, energy-saving design standard for the heating of public buildings DBJ 01-621-2005). Apart from the national standards, there are specific standards for the different climate zones in China:

The "Energy Design Code for Heated Residential Buildings" (JGJ 26-86) of 1986 was issued for the extremely cold and cold zones. The goal was a 30 percent decrease in energy consumption relative to "base buildings" constructed in 1980-81 (Lang 2004, 1192). The standard was revised in December 1995 and renamed "Energy conservation design standard for new heated residential buildings" (JGJ 26-95). The new increased energy-saving target was 50 percent. A table allows constructors to easily determine the heat-transfer coefficients of their building's envelope (Lang 2004, 1192). To assure compliance with the standard, the Ministry of Construction (now MOHURD) approved the "Standard for Energy-efficiency Inspection of Heated Residential Buildings" (JGJ 132-2001) in

February 2001. It specifies inspection and testing methods to serve as a guideline for inspectors. In October 2000, the Ministry approved the "Technical Specification for Energy Conservation Renovation of Existing Heated Residential Buildings" (JGJ 129-2000), a guideline for the retrofitting of existing buildings both with and without central heating systems that are located in the extremely cold and cold regions (Lang 2004, 1193 f.).

In 2001 and 2003, the "Design Standard for Energy Efficiency of Residential Buildings in the Hot Summer and Cold Winter Zone" (JGJ 134-2001) and the "Design Standard for Energy Efficiency of Residential Buildings in the Hot Summer and Warm Winter Zone" (JGJ 75-2003) were approved by the Ministry of Construction. Both include the 50 percent energy-saving target. Standard JGJ 134-2001 contains sections on indoor thermal environments, energy efficient building designs, and heating ventilation and air conditioning (HVAC) systems. It refers to newly constructed buildings as well as retrofits and renovations in the hot summer, cold winter zone. The standard is both performance-based and prescriptive in defining either the allowable energy consumption per square meter or the allowable heat-transfer coefficient of the building envelope as well as the minimum required energy efficiency of heating and cooling devices (Lang 2004, 1194). Standard JGJ 75-2003 differs only slightly from JGJ 134-2001. It also contains performance-based and prescriptive measures but focuses more on shading coefficients and glazing requirements as solar heat gain is a very important issue in the hot summer, warm winter region (Lang 2004, 1195).

4.3 Economic instruments

Economic instruments are a tool for promoting energy efficiency in buildings that make use of market mechanisms, such as fiscal incentives (subsidies) and disincentives (taxes), as well as tradable emission permits. They are more cost-effective and efficient than command and control instruments, but their real advantages can only be realized over time. Market mechanisms permit the Chinese government to provide companies and households with a continual incentive in order to improve energy efficiency. They encourage the use of new technologies, while allowing a greater flexibility to adapt to the targets (Harrington / Morgenstern 2004, 13-17).

This following sub-chapter aims to map the economic instruments used by the Chinese government on the national and local level to create incentives for EEB investments. As many economic instruments are actually still in the planning process, the following chapter gives an additional overview on the economic instruments which the government plans to introduce.

4.3.1 Economic instruments at the national level

In the past, economic instruments only played a minor role in China's policy to enhance EEB. Since 2007, however, the Chinese government has shown a strong political will to promote the use of market mechanisms for EEB investments. In 2007 the Chinese government allocated 1.6 billion RMB[4] to EEB and increased the entire budget to 2.5 billion in 2008. According to the Ministry of Finance (MoF), five EEB schemes actually receive funding from the MoF and MOHURD (Econet China 2008d):

1) Financial support for the retrofitting of existing buildings (see Box 2);
2) Tax refunds for companies that promote EEB;
3) Financial support for model cities: Shanghai, Beijing, Tianjin and Shenzhen to meet the 65 percent building standard;
4) Funding for the development of regulations in public buildings and the establishment of monitoring mechanisms for model projects;
5) Model projects for the use of renewable energy: developers which comply with the 65 percent standard can apply for funding.

> *"We plan to retrofit 150 million square meter of existing buildings. For this, we will allocate a substantial budget."*
> (MOHURD official)

4 1.6 billion RMB equate to 146 million Euro (November 2008).

Box 2: Financial support for the retrofitting of existing buildings

To support local governments in their retrofitting efforts, the MoF, together with the MOHURD, put forward the fiscal policy of using central budget funds as incentives to encourage retrofitting. In 2007 a total of 900 million RMB[5] was earmarked for subsidizing the installation of heat metering devices (Qiu 2008). The subsidizing scheme, which came into effect in December 2007 and which includes 14 different provinces of the cold and severe cold heating zones of Northern China, covers different areas of retrofitting such as the heat-provision part, the building envelope and the installation of heat meters. The funds are transferred directly to provincial governments which carry out the retrofitting. At the provincial level, they are administered by the energy office of the local construction authority.

The total amount which provincial governments can receive depends on the following variables:

- Climate zone: provinces in the severe cold zone can receive up to 55 RMB as a base amount per square meter (sqm) compared with 45 RMB[6] per square meter for provinces in the cold zone.
- Timeframe: the scheme awards the swift adoption of retrofitting measures. If the work is finished before 2009, the amount will be multiplied by the factor 1.2, while one year later, the factor 1.0 is applied. Finishing by 2011 means that the factor is 0.8.
- Number of components: in total, there are three different areas which are supposed to be retrofitted and which are weighed in determining the total amount to be paid: thermal insulation of the building envelope (60 percent), heat meters (30 percent), heat-provision pipeline-system including the kettle and thermostats (10 percent).
- Amount of energy saved: the total amount is weighed 30 percent compared with 70 percent with respect to the number of components. After retrofitting, the amount of energy saved is to be verified.

Additionally, 6 RMB per square meter can be paid in advance for the installation of thermostats.

Formula: subsidy = base-amount X [(sqm X weight X 0.7) + (sqm X factor energy saved) X 0.3] X time factor
Base amount: 45 or 55 RMB, depending on the climate zone, sqm = area that was retrofitted
Weight = 1, if all three components were retrofitted (0.6 for the building envelope, 0.3 for the installation of heat meters, 0.1 for the heat-provision pipeline-system), time factor = 1.2, 1.0 or 0.8

5 900 million RMB equate to 82 million Euro (November 2008).

6 55 RMB equate to 5 Euro, 45 RMB equate to 4.10 Euro and 6 RMB equate to 0.55 Euro (November 2008).

4.3.2 Economic instruments at the regional level

Apart from the national government, local governments are increasingly engaging in EEB funding. Economic instruments are also used as a tool to give incentives for energy efficiency investments, as is shown by the following examples:

Tangshan – funding for retrofitting

In Tangshan, the local government plans to pay a subsidy of 50 percent for retrofitting. Currently, the MoF and MOHURD cover 45 RMB[7] per square meter, about 15 percent of the total costs. The local government plans to pay the increment. The project's start is planned for 2008, going district by district, and will eventually be expanded to the whole city in the future.

Tianjin – subsidies for demonstration projects

In Tianjin, EEB demonstration projects can receive a subsidy of 50,000 RMB[8] as of July 2007. 20 projects benefited from this policy in 2007.

Anhui province - favorable tax policy

The local government of Anhui province announced that in 2008, companies which invest in energy-saving technologies or which construct or rebuild energy efficient buildings can apply for tax rebates. In total 35.8 billion RMB[9] are planned to be distributed to 475 energy-saving and comprehensive use of resources projects (Econet China 2008b).

4.3.3 Planned economic instruments

In his new year's speech Qiu Baoxing, Vice Minister of Construction (now MOHURD), announced the plan to establish further financial encouragement systems to enhance energy-efficiency in construction.

7 45 RMB equate to 4.10 Euro (November 2008).

8 50,000 RMB equate to 4,550 Euro (November 2008).

9 35.8 billion RMB equate to 3.2 billion Euro (November 2008).

According to the new draft regulation for EEB (Chapter 6, Article 49), the central and local governments plan to provide funding for five areas in particular (Qiu 2008):

1) Research and development for the development of standards and for demonstration projects
2) Energy auditing of governmental buildings and large scale commercial buildings
3) Retrofitting of existing buildings
4) Renewable energy in buildings
5) Local production of energy-saving building materials, appliances and products

The draft regulation for EEB defines how economic instruments should be used:

- Low interest loans should be offered to demonstration, renewable energy and retrofitting projects (Article 50)
- Tax reductions should be provided to demonstration, renewable energy and retrofitting projects, as well as all buildings surpassing the 65 percent standard (Article 51)

Detailed rules are expected to be formulated by MOHURD in cooperation with other related ministries. Furthermore, the government is exploring alternative funding schemes for EEB investments, such as the Clean Development Mechanism (CDM). The CDM might be a powerful instrument for the provision of capital for EEB in the future, but up to date no CDM project has been implemented in the building sector in China.

4.4 Informational instruments

Informational instruments aim to improve the understanding and awareness of EEB. As *"information and education are key elements to change knowledge into action"* (World Business Council for Sustainable Development (WBCSD) 2007, 29), the use of informational instruments is an important strategy for the Chinese government. The implementation of EEB policies and goals can be supported through labeling and certification programs, through information campaigns and demonstration projects. This sub-chapter aims to map the informational instruments used by the Chinese government to promote the implementation of EEB policies.

4.4.1 Labeling programs

Different labeling programs are used in China to inform end-users about the energy efficiency of buildings and electric appliances. They can be distinguished into mandatory energy labels and voluntary endorsement labels (certification).

a) Mandatory energy labels for electric appliances

In China, the history of labeling programs to inform end-users about the energy efficiency of appliances is a very recent one. The "China Energy Efficiency Label" was successfully established and used in 2005 on a first batch of products (refrigerators and air conditioners). The label rates the energy efficiency of the appliance in terms of a set of energy efficiency ranks. These go from 1 to 5 on the label. Rank 1 is the most energy efficient, while rank 5 is the least efficient. The label is now compulsory for all listed products. It is forbidden to sell products without this label on the Chinese market (Minghong / Aixian 2005, 1 ff.).

b) Voluntary endorsement labeling (certification)

Electric appliances

Following its establishment in 1998, the China Certification Center for Energy Conservation Products (CECP) formalized a comprehensive system of certification requirements and procedures under which an endorsement label is granted to products that meet both the quality assurance and energy performance specifications. In 2000, CECP granted its energy conservation label to 67 models of air conditioners that were produced by 10 manufacturers. According to CECP estimates, labeled air conditioners consume 10 percent less electricity on average than non-labeled products (Lin 2007).

Buildings

Green Building Evaluation Label

In late 2007, the MOHURD released China's first national "Green Building Evaluation Label", to offer a market-based incentive to promote environmental sustainable buildings from the top down. The labeling system aims to introduce the term "Green Building" as a common procedure of construction project management and to make the market for sustainable buildings in China more transparent (Qiu 2008). While the new Chinese label is similar to the Leadership in Energy and Environmental Design (LEED) (see Box 3), it intends to be more rigorous than its American counterpart and to broaden the application of green building labeling beyond multinational office buildings and high-end apartments.

The building evaluation addresses five categories: land-use, energy, water, construction materials, and indoor air quality. Primary objectives are the reduction of the waste of resources; reducing pollutants, particularly carbon dioxide; and providing users with a healthy living environment. The label uses a rating system represented by stars, with three stars standing for the highest level of sustainability and one star for the lowest (Qiu 2008).

Box 3: LEED Certification

The Leadership in Energy and Environmental Design (LEED) Green Building Rating System is a third party verification by the U.S. Green Building Council (USGBC), which has become popular among Chinese developers. The USGBC is a non-profit organization composed of more than 13,500 organizations from across the building industry committed to expanding sustainable building practices.

LEED is a voluntary informational instrument that, on the one hand, aims to help home owners to measure and manage their properties according to green building guidelines and, on the other hand, serves as a marketing tool for developers and as a guide for the decision-making process of potential home buyers.

LEED is a performance-oriented rating system where building projects earn points for satisfying criteria designed to address specific environmental impacts inherent in the design, construction, operation and management of a building. LEED promotes a whole-building approach where energy efficiency forms only one of the five rated categories. According to their number of points, rated buildings can earn a LEED Certificate in four categories: Certified, Silver, Gold, and Platinum (USGBC 2008).

Building Energy Efficiency Label

In March 2008, at the 4th Green Building Conference, Qiu Baoxing, China's Vice Minister of Housing and Urban-Rural Construction, introduced a new “Building Energy Efficiency Label” to the public. The label is to serve four main goals: 1) the objective reflection of a building’s energy consumption, 2) guidance on the development direction of the construction and real estate industries, 3) improvement of the public comprehension and cognition of EEB and 4) enhancement of the supervision of EEB and implementation of incentives.

The label is mandatory for government buildings and large public buildings as well as for applicants for national or provincial EEB demonstration projects or green building labeling, other residential or commercial buildings can voluntarily apply for the label.

The energy performance of a building is judged according to a five star rating system, where five indicates the best energy performance. The basic item to be met is an energy efficiency performance rate of 50 percent or above, according to the HVAC energy consumption per square meter. Further stipulated items (e.g. boiler and window efficiency) must be met by the building envelope and HVAC system. In addition, the energy performance can be topped off by additional scoring items for energy-using systems and technologies exceeding the current EEB standard (e.g. renewable energy).

The construction administration of the National Council will be responsible for the implementation and supervision of the energy efficiency evaluation and labeling of civil buildings nationwide, while the construction administration of the local government will perform this task at the local level. Responsible for the administration of the “Building Energy Efficiency Label” will be the planned “China Green Building Committee” in form of a public-private partnership (Qiu 2008; Pasternack 2008).

4.4.2 Demonstration projects

Demonstration projects such as the retrofitting or construction of energy efficient buildings are a frequently used informational instrument in China. On the one hand, they are supposed to be a role model for construction companies and developers in an illustrative sense in order to show how EEB standards can be realized. On the other hand, demonstration projects aim to raise the awareness of building residents of the benefit and co-benefits of enhancing EEB. In addition, model projects can lead to experience gained and produce “best practices”, which can be fostered through information exchange between local governments or other actors involved in the implementation of EEB policies and measures. The different projects can be divided into three categories: model cities and projects, single demonstration buildings and demonstration programs.

a) Model cities and projects

The MOHURD has chosen four model cities, namely Shanghai, Beijing, Tianjin and Shenzhen, to gain experiences and derive best practices for the implementation of EEB policies and measures in different climate regions. Furthermore, the MOHURD has introduced a “National Award for Green Building Innovation” to push the development of best practices. In addition, the MOHURD supports model projects by local governments that are enhancing EEB. One model project will be described here in a summarized version:

Tangshan

Together with the German Ministry for Economic Cooperation and Development, the MOHURD is carrying out the project “Energy efficiency in existing buildings” from 2005 until 2010. The project focuses on residential buildings in urban areas within Northern China. The aim is to improve energy efficiency by integrating retrofitting concepts, technologies and financing modes. To achieve these objectives the project offers advisory services regarding policies and standards, the introduction and transfer of technology, cooperation with industry as well as knowledge management (GTZ 2007).

The heart of the project has been the successful retrofitting of residential plots in Tangshan, Hebei Province. According to interviews with a variety of actors[10] involved in the project, three main benefits can be observed: 1) the project has served the national government as a role model and experience ground for successful retrofitting practices, 2) it has served to raise the knowledge of residents both of already retrofitted and of non-retrofitted buildings about the benefits of EEB and 3) it has fostered "best practices" and extensive knowledge exchange between the local government of Tangshan and other local governments.

b) Single demonstration buildings

Apart from model cities and projects, there are several single demonstration buildings in China which serve the same aims as pilot cities, just on a smaller scale. Even though the projects pertain to public buildings, they also contribute in increasing public awareness and are therefore of importance for this study.

The central government and the Beijing and Shanghai local governments have used the Beijing Olympic Games 2008 and the World Expo 2010 in Shanghai as events to promote EEB and to raise public awareness for this topic. This has been done by constructing single energy efficient demonstration buildings. The efforts being undertaken are described as follows in a summarized version:

Beijing: Olympic buildings and village

As part of a campaign to improve China's environmental image and to counteract concerns about the effect of air pollution on athletes and spectators alike, the Beijing Olympic Games 2008 have been dubbed "The Green Olympics" by the Beijing Organizing Committee for the Games of the XXIX Olympiad (BOCOG).

In the field of EEB, China's aim is that the Olympic venues "*adopt efficient technology to conserve energy and use energy properly, such as using advanced architecture to decrease the heat radiation, making good use of solar energy, natural ventilation and the possible technology to conserve energy*" (BOCOG 2008)

10 Interviewed actors involved in the Tangshan demonstration project: households, local government officials, experts from the German international cooperation agency GTZ.

Furthermore, in the Olympic Village efforts are being made to conserve energy. One example is that the Olympic Village relies on a heat exchange heating and cooling system that makes use of the heat produced in the sewage treatment system. By using high-level insulation for the enclosure structure, adopting advanced energy supply technology and full utilization of renewable energy, BOCOG hopes to improve energy efficiency substantially (BOCOG 2008).

Shanghai: Expo buildings (Puijiang Intelligence Valley and Wen Yuan)

Puijiang Intelligence Valley (PIV) was built in 2006 as a new business park in the southeast of Shanghai. It covers an area of 1.5 km². All buildings are consistent with ecological and sustainable requirements and use energy efficient technologies for heating and cooling. As the first buildings outside of Germany, Puijiang Intelligence Valley received the German Energy Pass (see Box 5) (Dena / CEEB 2007, 222-230). The Wen Yuan building was constructed in 1953 on the site of the Tongji University in Shanghai and was reconstructed according to EEB standards. Until the beginning of the world exposition Expo "Better city, better life" 2010 in Shanghai, the energy efficiency of Wen Yuan will be documented. Therefore, it offers sponsors from the building industry the possibility of demonstrating their abilities (Dena / CEEB 2007, 231-241).

c) Demonstration programs

The MOHURD had set up its own demonstration program, the "National Comfortable Housing Program", from 1995 to 1998. The aim of the program was primarily to advance quality design standards and high quality construction methods and materials. Through this project the Chinese government invested over 220 billion RMB[11] and provided over 260 million square meter of floor area to households. In Beijing city, about 52,000 households, which had a floor area per capita of less than four square meters, had their living standard improved (Meng / Feng 2005, 431; Rousseau / Chen 2001, 300).

11 220 billion RMB equate to 20 billion Euro (November 2008)

4.4.3 Information campaigns

At the moment, information campaigns regarding EEB are carried out much more as single local components than as a nationwide broad campaign by the central government. This might be due to the different regional conditions in the different climate zones and due to the political, administrative and legal structures. In addition, the national government tries to spread information through national EEB conferences and workshops.

Local campaigns

Local government officials stated that an information campaign on the reform of the heat billing and metering system in northern China has been carried out via newspapers and TV reports. In addition, a Beijing official introduced us to the local government's campaign "Energy conservation doctor", where experts give advice to households on how to improve energy efficiency in their home.

National conferences and workshops

According to a ministry official, the MOHURD has carried out a variety of workshops to introduce new standards to officials from provinces, on the implementation of standards and statistics, energy auditing and green buildings. In addition, the MOHURD is trying to increase architects' awareness of energy conservation codes by distributing a monthly newsletter to licensed architects (Glicksman / Norford / Greden 2001, 98).

Furthermore, since 2005 the MOHURD, in cooperation with other state ministries, has organized the "International Conference on Intelligent Green and Energy Efficient Building" and the aligned Exposition of new EEB Technologies and Products. The conference acts as a platform to discuss developments, best practices and technical innovations concerning EEB at the national and international level and aims to bring energy efficient technologies, living and production styles to mainstream attention in China (Chinagb.net 2008c; Chinagb.net 2008d).

5 Factors influencing the implementation of EEB policies and measures in China

The implementation of EEB policies in China is way below its potential. According to data from the MOHURD, the implementation rate of standards has already improved over the last few years. From 21 percent compliance with building standards in the construction and 53 percent in the design stage in the year 2000, the compliance rate has increased to 71 percent and 97 percent, respectively, in 2007. This is a considerable progress, but experts, researchers, and building professionals state that these numbers are overestimated and do not reflect reality. Also, government officials admit that the implementation still has room for improvement.

The reasons for the implementation gap are manifested in the political and in the economic sphere as well as being intensified by informational deficits, cultural specifications and the actors' constellation. Based on the outlined determinants of EEB implementation, this chapter applies the determinants onto the Chinese case. The aim is to paint a precise picture of the complex interaction of EEB relevant actors in China and the structures within which they interact. Emanating from our intensive literature research and especially the interviews conducted in China, we identified the main barriers and promoting factors for the implementation of EEB policies and measures.

This chapter commences with the evaluation of the legal environment and the enforcement of EEB policies and standards (5.1). Then economic determinants such as costs and market transparency are analyzed (5.2). The following sub-chapter identifies barriers and opportunities which derive from cognitive-informational determinants such as the distribution of information, knowledge and awareness (5.3). Additionally, the cultural determinants and factors linked with lifestyle and behavior are investigated (5.4). Specifics of the Chinese housing construction sector and its value chain are evaluated in the last sub-chapter (5.5).

5.1 Legal environment and enforcement of EEB policies and measures

The legal environment and the enforcement of EEB policies is the main factor affecting the implementation of EEB policies. The determinants in this sphere derive from both the political as well as institutional frameworks. The determinants take effect on the national and local level where the policy formulation and the actual implementation take place. Apart from the governance arrangements, administrative structures and procedures regarding EEB on these two levels, the political actors are illuminated more closely: i) the central government, i.e. the MOHURD, who is the key actor for developing EEB strategies and cooperating with other policy fields and non-governmental actors and ii) the province and municipality governments that are responsible for implementing those strategies at the local level.

5.1.1 Legal environment and enforcement at the national level

1) Commitment to enhance EEB

A pivotal factor promoting the implementation of EEB policies at the national level is the strong commitment of the central government to enhance energy efficiency in buildings. There is wide agreement that its primary motivation to enhance EEB is driven by the concern that energy supplies need to be secured plus the mitigation of local air pollution.

The strong political will of the central government is evident in several areas. The government has enacted several policies and measures as well as having improved existing codes and standards in order to increase EEB. Several new informational and economic instruments have been created. The central government has not only enacted new laws and policies, but also reformed outdated policies, as for example the heat billing and metering system in Northern China, which prevents the billing of the consumed energy according to the actual consumption.

To support the legal renewals the government intends to further enhance the institutional structure. In March 2008, plans were published to create a new State Energy Commission to integrate China's energy management supervision and policies (Econet China 2008a). Furthermore, in January 2008, Qiu Baoxing, Vice Minister of MOHURD, announced the launch of the China Green Building Council administering the country's new green building labeling system.

The national government's engagement to enhance energy efficiency in buildings is also expressed by its openness to involve actors beyond the political-institutional sphere. Especially NGOs, research institutes and construction or building material companies have in many cases pushed forward the development of standards, contributed to their formulation or run their own pilot projects.

2) Monitoring mechanisms

> *"Monitoring has become better over the years but it is still too simple. About 90 percent of the buildings are not monitored at all."*
> (Chinese entrepreneur, Beijing)

A great barrier for the implementation of EEB polices are weak monitoring mechanisms and a resulting culture of non-compliance. In our interviews we found that the monitoring, which aims to control the compliance with energy efficiency standards in new buildings[12], is not efficient enough or not carried out at all. The local monitoring agencies as well as the supportive "Specialized National Inspection on Building Energy Efficiency", which are in charge of supervising the selection of new buildings by random sampling, face four main problems that complicate the monitoring process:

- The monitoring process requires a lot of human and financial governmental resources which are both unavailable to the full extent needed. This problem is heightened further through the large number and speed of new building projects, which creates a great necessity for monitoring.
- The construction process is extremely complex, reaching from the design stage to the actual construction. This complexity is also reflected in the monitoring process. According to information we received from a city government official, the construction process requires three stages of monitoring: First, the blueprints have to be

12 Monitoring mechanisms only exist for new buildings. Existing buildings have to be retrofitted, but up to now there is no institutionalized monitoring of the process.

handed in to an independent private institution. This institution reports to the government (i.e. the local building authority) which then checks the plans a second time. In the second step the construction site has to be checked by special teams from public or private monitoring agencies and, third, the compliance with buildings standards has to be rechecked after the building has been completed. In some cases a private enterprise is entrusted with the monitoring task. Very often there is a large discrepancy between the construction design and its final realization.

- Methods to measure the energy consumption of buildings are still hardly available.
- Many experts and buildings professionals stated that the monitoring agencies are susceptible to bribery.

These problems lead to weak and incomplete monitoring and create a culture of non-compliance, ending in a race to the bottom: developers and construction companies see that they can get away with not complying with the standards. Other actors feel that they are now at a competitive disadvantage and therefore are, in their eyes, pressurized to follow. According to government officials, the MOHURD is aware of gaps in its monitoring system and plans to form six to ten expert groups to enhance monitoring within 30 provinces by the end of 2008. Furthermore, Vice Minister Qiu Baoxing recently announced that he will name and shame cities that fail to meet standards and revoke licenses of any firms that violate the regulation (China Daily 2008). Whether these plans are sufficient to improve the nationwide monitoring process remains to be seen.

3) Legal enforcement

The legal enforcement of penalties in the case of non-compliance with building standards is insufficient. Officially there are legal penalties, but in practice they are hardly enforced due to the weak legal system. This is related to the Chinese legal tradition: it was customary that decisions were made by influential or respected individuals rather than on the basis of laws or regulations. The Chinese legal system has indeed undergone reforms in the last centuries, but the traditional behavior needs time to change. Still, many decisions are taken by individuals which are driven by short-term and profit orientated considerations (Richerzhagen / Scholz 2007, 13). Furthermore, there are other factors which limit the efficiency of courts such as conflicting or inappropriate legal norms, the lack of an all-embracing and up-to-date record of legal norms and an inadequate vocational training for judges (Sha / Deng / Cui 20002000, 7). Another challenge is the widespread corruption within the building sector, which is generally the sector most affected by bribery worldwide, as the following table shows (Transparency International 2002). This is also the case in China, as many experts in our interviews confirmed.

Table 1: Bribery by business sectors – by size of bribe, 2002

Among the business sectors mentioned previously, which are the two sectors where the biggest bribes are likely to be paid?

Total sample 835	
Public works/construction	46 %
Arms and defense	38 %
Oil and gas	21 %
Banking and finance	15 %
Real estate/property	11 %
Pharmaceuticals/medical care	10 %
Power generation/transmission	10 %
Telecoms	9 %
IT	6 %
Forestry	5 %
Mining	5 %
Transportation/storage	5 %
Heavy manufacturing	4 %
Agriculture	3 %
Fishery	3 %
Civilian aerospace	2 %

Note: The results reflect the percentage of respondents who mentioned the particular sector.
Source: Transparency International (2002)

4) Distribution of competences and coordination in the energy sector

The lack of a single institution in charge of coordinating energy policy at the national level is another barrier in the political-institutional arena. Instead, the administration of energy efficiency is decentralized within different governmental departments: Up to now, the NDRC was responsible for the general energy efficiency strategy and industrial energy efficiency, while the MOHURD was in charge of energy efficiency in buildings. Other ministries were responsible for energy efficiency administration in their respective industries or working fields. The cooperation of government departments has often been characterized as problematic by our interview partners due to the following problems:

- Overlapping competences
- Lacking coordination
- Diverging interests
- Perceived lack of resources on the part of the MOHURD

Two interview partners mentioned power struggles between MOHURD and the NDRC resulting in a lack of resources for the weaker MOHURD and overlapping competences in the EEB sector. In March 2008 the central government announced that a new State Energy Commission will be created to agglomerate Chinas energy policy in one institution (Econet China 2008a). The new commission was mentioned frequently in the media and by many of the interview partners.

5.1.2 Legal environment and enforcement at the local level

Even though the policies and standards are being developed in Beijing, they need to be implemented at the local level. Provincial governments and construction divisions in the cities are facing the challenge of having to deal with the details and difficulties which the realization of policies brings with it. We found that the implementation rates for building standards but also the status of regulations and policies varies greatly between different provinces and municipalities (Langer 2004; Lang 2004, 1194). According to statements of a MOHURD official, especially smaller cities face difficulties in implementing EEB policies or measures. We identified four main factors that influence the implementation of EEB policies at the local level:

1) Commitment to enhance EEB

As on the national level, a positive influence on the implementation of EEB policies is the local governments' commitment to enhance EEB. Many local governments try to enhance their reputation with regard to energy efficiency and stand out with their own EEB policies and measures. According to information we received from MOHURD, this is shown through different initiatives.

- Enactment of individual regulations or government orders: according to the MOHURD, three provinces and two cities (Shanxi, Chongqing, Urumqi, Wuhan and Shenzhen) developed regulations on EEB, nine provinces drafted regulations on EEB concerning energy saving and the innovation of building materials, 23 provinces issued government orders on EEB;
- Local governments enact regional standards exceeding the national ones (e.g. the city government of Beijing has set a standard of a 65 percent reduction in heating and cooling energy for new buildings instead of the national one which is 50 percent) (Green Dragon Project 2008);
- Local governments have their own economic incentive programs. For example, in Tianjin the city government has issued the "Green building demonstration project management rules" in June 2007. According to these rules, 20 EEB projects were able to receive funding of 50,000 RMB in 2007. It worked in the form of an incentive structure, 30,000 RMB were paid before construction and 20,000 RMB afterwards;[13]
- Local governments start their own demonstration projects. For example, in Tangshan the city government runs a retrofitting project to enhance energy efficiency in existing buildings together with the GTZ.

Despite all of these good efforts, it also has to be critically mentioned that up to now, eleven provinces and regions have not put energy efficient buildings into the general target of per unit GDP energy consumption reduction. And not all regions which have worked out individual regulations have put them into force (Econet China 2008b).

13 50,000/30,000/20,000 RMB equate to 5,735/3,441/2,294 Euro (November 2008)

2) Financial and human resources

Insufficient financial and human resources are perceived as being an important barrier by the local government officials in general (Hofmann / Meyer 2007, 2; Kahl 2002, 2; 8+9). Due to financial constraints, local civil servants often do not obtain training and therefore no concrete implementation guidelines are passed on to them. In consequence, they lack the capacity to interpret and implement laws and often have no understanding for the necessity of EEB policies. Therefore, local officials often feel overwhelmed by their tasks and do not understand the urgency and importance of an energy efficient building design (Lang 2004, 1195; Kahl 2002, 2; 8+9). Another problem connected with the lack of human and financial resources is that some provinces and cities have no special management units for EEB and not enough resources to carry out an effective monitoring (Langer 2004; Lang 2004, 1194).

To address the problem the Chinese government has initiated capacity building programs for local government officials. On the one hand, capacity building is provided through the exchange of information and experiences made between different cities or provinces, as happened in the Tangshan retrofitting project for existing residential buildings, where delegates from other provinces or cities visited the project on a continuous basis. On the other hand, as MOHURD officials state, the ministry organizes workshops for local government officials where they receive training on new standards and how to implement them. However, other interview partners underlined that the training measures are not sufficient and that local officials lack concrete implementation guidelines.

3) Prioritization of economic interests

On the local level, economic interests are often prioritized leading to the problem that environmental and energy issues have to take a seat back. Among our interviewees three main reasons emerged for this:

- Local leaders have been assessed based on their economic performance since the 1980s. To achieve a good rank within the national economy and to be promoted they consequently put a high priority on economic issues and GDP growth rather than on energy efficiency.

- Local leaders want to foster their region's or city's development by attracting investments, so there is an incentive for them to encourage industry which will help them to meet their GDP targets. By selling land for construction projects they can increase their governmental budget. Therefore, activities of enterprises are sometimes promoted even though they do not comply with energy efficiency standards (Hofmann / Meyer 2007, 3).
- In some cases government officials have a share in construction companies and are not interested in an effective monitoring of housing projects as this would contravene with their personal economic interests (Hofmann / Meyer 2007, 3; Glicksman / Norford / Greden 2001, 98).

An opportunity for improvement could be the draft amendment to the Energy Conservation Law which suggests that work carried out by local government officials in energy conservation should be integrated into the assessment of their political performance (Chinagb.net 2008b). It however has to be critically observed whether this renewal leads to a change of behavior by the local officials or rather leads to the necessity of having to manipulate EEB statistics. This has happened with GDP statistics in the past (Pan 2006). This danger might be especially given considering the pressure local officials face. Officials who cannot reach the goals have to pay penalties or even resign. This therefore could increase the probability of manipulating statistics.

4) Conflicting directives due to fragmented vertical authorities

The political and institutional EEB structure is characterized by fragmented vertical authorities. The MOHURD is in charge of EEB policies at the national level, the respective province government at the provincial level. At the municipality level, local building authorities or energy bureaus are responsible for implementing EEB policies and measures. On the one hand, they have to consider the general national EEB strategy. On the other hand, as we were told in interviews, they are only bound to and paid by the provincial government. This results in a weak role of the MOHURD, the danger of conflicting directives for local building authorities and the habit of passing responsibilities from one political level to the other.

5.2 Economic parameters affecting investments in EEB

Apart from the political factors, economic factors have been an important determinant for not achieving energy efficiency within buildings in the past. Distorted pricing schemes for energy, high prices of EEB technologies, and limited access to capital for investment have been major barriers to EEB improvements. In the last couple of years, the Chinese economy has undergone rapid changes and has developed from a truly socialist economy to a socialist-market economy (Glicksman / Norford / Greden 2001). Economic growth and market reforms have changed the economic framework conditions on the relevant markets and have created new opportunities and challenges for the implementation of EEB policies.

The following chapter is an analysis of economic parameters which affect investments in three key fields:

- New energy efficient buildings
- Retrofitting
- Air conditioners (ACs)

We identified six main economic parameters that have a particular influence on EEB: Costs of EEB investment, home ownership, energy prices and the system of heat billing and metering, market transparency, economic incentives for developers and financing options for EEB investments.

5.2.1 The costs of EEB investments

The costs of EEB investments relate to the three fields (new buildings, retrofitting, ACs). We found out that costs of EEB investments are no major problem for new energy efficient buildings, whilst however constituting a major barrier for retrofitting and the dissemination of air conditioners.

1) Low incremental costs for new energy efficient buildings

Substantial energy savings in new buildings in China can be achieved with little cost through improved building designs and good management practices. All interviewed experts agreed that additional costs for low-tech options to enhance EEB are relatively low. Experts predict that the costs for EEB investments, which can save up to 60 percent of the energy consumption, are about five to seven percent higher than in a conventional design (chinagb.net 2008b). The incremental costs vary with the technology applied and the overall price of the building. Architects agreed that costs for EEB investments in China could even be reduced further if energy efficient options were incorporated into the design of buildings from the very beginning.

2) Retrofitting existing buildings – a costly option

Compared with enhancing energy efficiency in new buildings, the retrofitting of old buildings is a costly option. The installation of external thermal insulation and especially having to change the one-pipe heating system to a two-pipe system is labor-intensive and requires a substantial investment. In the GTZ project in Tangshan, the average costs for a retrofit (installing an exterior thermal insulation, insulating the roof, replacing doors and windows and renovating the internal heating system) were about 365 RMB[14] per square meter, not considering any extra or additional costs (Sino-German Technical Cooperation "Chinese Energy Efficiency in Existing Buildings" Project 2007).

3) High costs for energy efficient air conditioners

China's room air conditioner industry has gone through a period of dramatic growth during the last years. Air conditioners have moved from a luxury item to an item that many households can afford. In Shanghai, the penetration of air conditioners has almost reached 100 percent (Long / Zhong / Zhang 2004). However, the market share of energy efficient air conditioners remains very low. The highest energy efficiency classes 1 and 2 account for only eight percent of the air conditioner market (IEA 2007a).

Financial constraints are the main barrier for market penetration of air conditioners. Costs for energy efficient air conditioners are much higher than opting for the standard system. NGOs and households affirmed that class 1 air conditioners are too expensive for ordinary people. The price of a class 1 air conditioner is about twice that of a class 5 air conditioner, whereby consumers save 60 percent on energy (China Daily 2007).

14 365 RMB equate to 42 Euro (November 2008).

5.2.2 Home ownership

Private home ownership in China is a potential promoting factor for investments in new energy efficient buildings, whereas it constitutes a hindering factor for retrofitting.

China has one of the highest home ownership rates in the world, largely as a result of the privatization of the public housing sector. About 50-60 percent of Chinese urban families own their homes (IEA 2007a, 8). Our research confirmed the strong popularity of real estate investments in China. As to the question whether they own or plan to buy an apartment in the future, all Chinese interview partners expressed the strong will to own an apartment rather than to rent one.

According to the IPCC report, private home ownership provides a powerful market-based lever for EEB investments as it offers the opportunity to use end-users' incentives for EEB investments (IPCC 2007). However, it is clear that other factors such as energy prices, the system of heat billing and metering, the intransparency of the market and the lack of awareness and capital still counteract the positive effects of private home ownership on EEB (World Bank 2001). In consequence, home buyers still have a low preference for EEB. Important factors for the buying decision of households are the price and location of the apartment, whereas quality and energy efficiency only play a minor role.

Furthermore, with regard to retrofitting we even observed a negative impact due to private home ownership. Private home ownership leads to collective action problems, which are one of the main barriers for retrofitting (see 5.5.2).

5.2.3 Energy pricing and the heat billing and metering system

Households are key actors for the implementation of EEB policies, but they lack economic incentives and information to invest in energy efficient buildings and appliances. Even though the extra costs in order to reach the 50 percent and 65 percent building standards are relatively low, it is enough to place green buildings at a competitive disadvantage as the vast majority of consumers lack economic incentives that would lead to them paying a premium for energy efficiency.

The energy prices and the systems of heat billing and metering in Northern and Southern China differ and therefore influence the investment decision of households in different ways. In Northern China the heat billing and metering system, which can be described as a social welfare system, is the main institutional barrier to EEB investments. The system gives strong disincentives for EEB investments due to the following reasons:

- Heat is often not paid by the residents, but by their employer
- Heat is not billed according to consumption, but by square meter
- Residents cannot regulate the room temperature
- Central heating is subsidized in China. The heating price for central heating is capped at 45 RMB[15] per square meter for the heating season. Households using individual heating systems in Northern China told us that their operating costs were above those for central heating.

The Chinese government has recognized the problem of disincentives and has put the reform of the heat billing and metering system at the top of its agenda. Experts told us that reforms are expected to lead to a 27 percent energy saving in the building sector once they are implemented and will create a substantial market for retrofits that will improve building energy performance.

In Southern China, both the costs for cooling and the costs for heating have to be paid according to consumption. Contrary to Northern China, the price for heating and cooling south of the Yangtze river depends on the market price for energy. The market price has increased in recent years as China has progressively cut its energy subsidies. In 2006 subsidies were reduced by 58 percent compared to 2005 (IEA 2007b, 279 f.). In consequence, residents now have an incentive to save energy.

Households stated that they try to save energy in order to save on energy costs by limiting the operating hours of air conditioners and by cooling only parts of the apartments. According to research by the Tongji University, about 30 percent of the electricity budget of a family is spent

15 45 RMB equate to 4.10 Euro (November 2008).

Box 4: Status quo and barriers for the heat billing and metering reform

Status quo

Despite the difficulties, some pilot cities such as Qingdao or Tianjin, which are supposed to fully implement the reform by 2010, have already made some progress and bill the consumed heat according to consumption. The first step of the reform, however, which relieves employers of paying for the heating of their employees and transfers the responsibility to the residents, has been taken in most of Northern China.

Barriers to the heat billing and metering reform

There are five main barriers which have so far impeded the full implementation of the long-planned reform of the Heat Billing and Metering System in Northern China:

1.) It is hard to exactly measure individual heat consumption of households and to determine socially acceptable tariffs. The question of heating tariffs is a particularly sensitive political issue because it involves the reduction of social benefits which hitherto were perceived as constituting a social right.

2.) Retrofitting of the existing building stock is a necessary precondition for the full implementation of the reform. Apart from involving many complex decision-making processes among numerous stakeholders, the technical change is very expensive. It is not clear who will pay for the retrofitting.

3.) Not only old buildings but also many new buildings lack the technical equipment necessary for individual heat metering.

4.) The heat providers, which are mostly state-owned, block the reform because they fear that their profit margins will shrink.

5.) Heat stations and the whole heat-pipe-system have to be renovated in order to be able to deal with the expected greater variations in heat demand due to individual regulation.

on air conditioning (Long / Zhong / Zhang 2004). However, the majority of consumers is not considering investing in energy efficient technologies. Many consumers in Southern China think that investments in energy efficient air conditioners will not have any payback effects. Product prices of energy efficient air conditioners are too high and households still use a very small amount of energy.

Therefore, EEB investments in Southern China would only pay back in the very long run. In spite of this, people's time horizon and the life-cycle of buildings is often shorter than the estimated payback period.

5.2.4 Market transparency

In the last couple of years, MOHURD has introduced new informational instruments, such as labeling systems for air conditioners and a label for green buildings in order to improve the transparency of the market for EEB. However, we encountered the fact that the intransparency of the EEB market is still one of the main barriers for investments. The energy passport, which has been introduced in Germany in 2008, might be an additional effective instrument to improve transparency within the Chinese building sector (see Box 5).

Indeed, most of the households we interviewed had very little knowledge about the EEB options, the price as well as the benefits and co-benefits of EEB. Several experts mentioned that households do not invest in EEB because it is difficult for them to evaluate the benefit they will get from an investment (see 5.3.1).

5.2.5 Economic incentives for developers to invest in EEB

We found that most Chinese developers pursue a short-term focus with regard to their building's financial value. Developers want to sell their buildings as fast as possible. Energy efficiency is only of importance to them if it is decisive in the buying decision of their clients, as in the case of the high-end market. For developers operating in the mass market, in contrast, energy efficiency is not important as it hardly plays a part in the buying decision of their clients.

An increasing number of high-end developers are engaging in green building projects. These developers argue that they can get a competitive advantage and an increased profit margin from EEB investments. High-end developers can use EEB as a marketing tool and selling point for their

Box 5: Best practices from Germany: the energy passport for buildings

The German energy performance certificate for buildings, the so-called energy passport, aims to bring more transparency to the real estate market. It provides all actors with reliable information on the energy requirements, the energetic quality and the CO_2 emissions of a building. Furthermore, the certificate gives concrete advice on how refurbishment can save energy and improve the energy efficiency rating of the building. These recommendations are supposed to be an incentive for retrofitting and energy saving measures. The energy passport for new buildings was already introduced in Germany in 2002. From the second half of 2008 onwards, existing buildings will also require an energy performance certificate when they are sold or rented out.

Home owners can choose between two versions of the energy passport:

1) For the demand-oriented energy passport the building is rated on the basis of its energy demand. Each building is assessed according to a standardized procedure. The building's envelope, construction materials and heating system are analyzed and, based on this data, the total heat loss of the building is determined The result gives an objective picture of a building's energy quality, independent of the behavior of individual consumers.The key values of the different buildings can be compared.

2) The consumption-oriented energy passport states the current energy consumption per square meter. For this type of energy passport, the corresponding data is determined on the basis of the heating bills of the last three years. The measured consumption depends on the behavior of the tenants and the number of people living in the building, so that this approach only provides limited information on the building's actual energy quality.

All actors can benefit from the certificate:

- Purchasers and tenants can estimate the expected energy costs of a building, before buying, constructing or renting it.
- Landlords, real estate agents and developers can use the energy passport as a marketing instrument.
- Home owners are informed about the energy quality of their buildings and can plan further steps for refurbishment.
- Architects, engineers and construction workers are provided with new fields of work.

Source: Dena (2008)

properties as is shown in the case of Modern MOMA (see Box 6). In this market segment consumers have a growing interest in the improved living quality offered by EEB. Compared to the high prices of their buildings in urban areas, the extra costs for EEB investments are minimal.

Mass-market developers, on the other hand, have almost no incentives to invest in EEB as they (1) have higher initial investment costs, (2) do not get a comparative advantage and (3) have no need to invest in EEB.

1) The initial EEB investment costs for developers in China are predicted to be about five to seven percent higher than in conventional design, plus, at the beginning, developers might face even higher costs. As energy efficient buildings are relatively new in China, building professionals and households still lack experience with the use of EEB technologies. Developers do not only have to provide additional funding for marketing campaigns to raise awareness among consumers but they also need to train building professionals, design institutes and architects in EEB.

2) Mass market developers do not get a comparative advantage from EEB investments as demand for energy efficient buildings in this market segment is still very low. Factors for the buying decision of households are the price and location of the apartment, while quality and energy efficiency only play a minor role. In consequence, even minimal incremental costs for EEB can place energy efficient buildings at a competitive disadvantage.

> *"No matter which technology you use in residential buildings, you can sell them".*
> (Developer, Beijing)

3) Furthermore, mass market developers have no need to invest in EEB. Developers state that they can sell residential buildings in urban areas, regardless which technologies are used. The building construction market is dominated by the sellers. Residents have little influence on the type of buildings they live in due to this market situation.

Box 6: **Modern MOMA – profitable and environmentally friendly**
The developer, Modern Group, has made the building's environmental-friendliness a top selling point for its luxury apartments. Its building project "Linked Hybrid", also known as Modern MOMA (Linked Hybrid), which will be completed in June 2008 shows how residential buildings in China can be both profitable for developers and environmentally intelligent. Modern MOMA ranks among China's three biggest building construction projects and contains apartments, offices, shops, and a movie theater. The building's sustainable features include geothermal heating, a wastewater recycling plant (to partially feed the site's sprawling garden), an elaborate indoor ventilation system that pipes in clean air, and the intelligent use of shade and daylight. The project will have the largest residential geothermal heating/ cooling and graywater recycling system in the world upon completion. The apartments cost around 23,000 RMB per square meter. The price is considerably higher than for comparable apartments. Buyers, thus far, are in no short supply; many of the apartments have already been sold before completion.
Source: Pasternack 2008

5.2.6 Financing options for EEB investments

Capital for investments in new energy efficient buildings is available. Many experts agreed that the availability of capital is no major problem for investments in new energy efficient buildings in China as the incremental costs for EEB investments are minimal. Indeed, many developers are not short of capital as they have benefited from the construction boom of the last years.

In addition, households have shown their financial capacities when it comes to paying high prices for buildings. Architects state that even though building prices almost quadrupled during the last years, demand for buildings still remains high. However, some experts affirm that high building prices have a negative impact on EEB. Even without investing in EEB technologies, homebuyers in China already spend entire life savings on new homes. Monthly mortgage payments are as high as 62 percent of real household income in Beijing (Glicksman / Norford / Greden 2001, 90). Therefore, households are often not able and not willing to pay additional costs for EEB investments, even though they are low.

Access to capital

Capital is available but it is not always accessible. The access to the private capital market is mainly limited to big developers. Households and small as well as medium-sized companies often have difficulties to get loans, even though investments would be economically beneficial (Glicksman / Norford / Greden 2001). Most financial institutions in China are not willing to finance EEB projects due to high transaction costs, the slow amortization of investments and the insecurity of the investment (Liang et al. 2007, 1105). In 2007, access to private capital for private investment in real estate was restricted even further by the government to cool down speculation on the real estate market.

In the case of retrofitting, for low-income and middle-income residents it is virtually impossible to receive a loan from a bank. While the amounts necessary for the investment are too high to be affordable for certain families, they are too low to be profitable for banks. This dilemma can be overcome by local governments if they offer special micro-credit schemes for retrofitting. For example, in the GTZ-Project in Tangshan residents were allowed to pay their contribution in smaller rates than possible at any bank (Sino-German Technical Cooperation "Chinese Energy Efficiency in Existing Buildings" Project 2007).

State funding for EEB investments

The provision of state-funding to promote energy efficiency in the building sector has increased significantly during the last years. New economic instruments have been introduced to promote the development of the EEB market, such as tariff cuts for companies, subsidies for developers surpassing the 65 percent standard and a funding program for retrofitting. However, most economic instruments are still in the planning process. The majority of developers and households still have no access to government funding and the information on existing economic instruments is very intransparent.

Alternative financing mechanisms for retrofitting

a) Energy Service Companies (ESCOs)

ESCOs, also known as EMCOs (Energy Management Companies), are an attempt to finance the enhancement of EEB by making use of market mechanisms. ESCOs engage in energy performance contracting. They negotiate an arrangement with a property owner that covers both the financing and management of energy-related costs. An ESCO develops, installs and finances projects designed to provide energy at a contracted level and fixed costs. Its compensation can be directly linked to the amount of energy that is actually saved.

Currently, ESCOs are being used in the Chinese public and commercial building sector but hardly in residential buildings. Nevertheless, in interviews, many experts suggested that ESCOs have a great potential to also enhance EEB in the residential building sector. One reason why the use of ESCOs in the residential building sector has been limited to date is that ESCOs face a lack of capital. To overcome this barrier, international donors such as the World Bank have tried to bridge the financing gap (World Bank 2001).

b) Clean Development Mechanism

> *"To some people, the CDM is a magic button that makes everything happen."*
> (Consultant, Beijing)

The Clean Development Mechanism (CDM) is one of three flexible mechanisms defined under the Kyoto Protocol. It allows industrialized countries with a greenhouse gas reduction commitment (e.g. EU member countries, Japan) to invest in projects that reduce emissions in developing countries such as China as an alternative to more expensive emission reductions in their own countries.

Even though there are no existing CDM projects in the Chinese building sector so far, CDM is perceived to have a great potential as a financing tool for EEB by generating Certified Emission Reductions (CERs) in retrofitting projects. A great variety of actors in China such as private consulting agencies, government institutions and development agencies are working on overcoming existing barriers for the use of CDM in retrofitting.

The CDM is still suffering from methodological problems, i.e. setting a baseline, measuring the exact amount of energy saved or defining the project boundary, and the comparatively high costs of projects in the residential building sector which are due to long approval periods and high coordination costs where many different apartment owners are involved.

c) The voluntary carbon market

A less complex option to tap private funds for retrofitting is the voluntary carbon market. In this market, companies, individuals or organizations purchase carbon offsets in order to reduce their carbon footprints. An individual can, for example, purchase carbon offsets to compensate for the greenhouse gas emissions caused by personal air travel.

In the same way as retrofitting projects can potentially generate CERs, they can also create voluntary carbon credits if carbon offset providers provide funds for retrofitting. However, currently, this practice is only a theoretical option because the voluntary carbon market is not being used as yet to finance retrofitting.

5.3 Information, knowledge and awareness

Knowledge about the benefit and co-benefits, technical measures and options to enhance EEB is an asset for public awareness and a necessary condition for the successful implementation of EEB policies and measures. The availability of knowledge depends on two main factors: first, the ability of the Chinese government and non-governmental actors such as the media, NGOs and companies to disseminate information and, second, the quantity and quality of the distributed information.

This chapter will focus on the informational factors which promote or hinder the implementation of EEB policies and measures in China. The following topics will be discussed: public knowledge and awareness of EEB in China (5.3.1) and the dissemination of EEB related information by non-governmental actors, namely the media, NGOs and companies (5.3.2).

5.3.1 Public knowledge and awareness of EEB

As several studies, including our own research, indicate (Liang et al. 2007; Lo / Zhao / Cheng 2006; Glicksman / Norford / Greden 2001) that public knowledge of EEB is poor. This leads to a lack of awareness of the possible impact of EEB on climate change and its co-benefits and to a low acceptance of energy efficient building products among residents, even though there are regional differences (Liang et al. 2007, 1101).[16] In our research we found that this is due to three main reasons:

1) Lack of knowledge of the co-benefits of EEB: There is far-reaching agreement among experts that consumers are not aware of the fact that they can reduce their energy costs and improve their living comfort by living in an energy efficient building and using energy efficient appliances. We found that residents living in energy efficient retrofitted homes in North China attach most importance to the improvement of the room temperature and better conditions for their health.[17] The emphasis on enhanced living comfort instead of reducing energy costs is due to the fact that heating is still not billed according to consumption. In addition, we noticed that even though in China it is a common practice to frequently replace the windows, people primarily do so in order to make their homes prettier as well as reducing dust and therefore do not necessarily install more efficient double-glazed windows.

2) Lack of knowledge of technical measures and options to enhance EEB: Residents need knowledge about technical measures and options to make purchasing decisions and to use appliances efficiently. We found that one major obstacle for investments in EEB is that people face great difficulties when attempting to evaluate the quality of energy efficient buildings as well as appliances. EEB often is invisible**.** Wall insulation, for example, cannot be seen and its benefits can only be experienced by residents over time. Therefore, households are not willing to purchase them. Furthermore, residents lack the technical know-how when it comes

16 Regional differences depend on the metering payment system for heating in north China, the quantity of energy consumed and climate characteristics (Liang et al. 2007, 1101).

17 Residents linked energy efficient retrofitting to the reduction of indoor humidity and mildew and therefore to improved health conditions.

to evaluating the quality of EEB products (e.g. double-glazed windows) and they do not trust in the market: in the past, the term "green building" has been used as a marketing tool in an inflationary way. Often, it referred to buildings which in fact were not energy efficient. In addition, simple technical measures to enhance energy efficiency such as shading are not commonly known in China.

3) Perception that EEB is too expensive: The costs for energy efficient buildings are often overestimated. Not only households, but key players in real estate and construction as well misjudge the costs and benefits of energy efficient buildings. According to a recent study conducted by the World Business Council for Sustainable Development (WBCSD), most of the key actors in China estimated the additional cost of green buildings at 28 percent above conventional construction costs – more than four to five times higher than the true cost difference of about five percent (WBCSD 2007, 18). On the household level, this perception is due to the fact that many developers also use the term "green building" as a marketing tool for high-end developments. Consequently, many interviewed residents perceived energy efficient buildings as a luxury good and did not even consider buying an energy efficient apartment for themselves.

5.3.2 Dissemination of EEB-related information by non-governmental actors

To improve knowledge and public awareness of the importance of enhancing EEB the actions of non-governmental actors are of outmost importance. Generally since the 1990's, the room for maneuver of non-governmental actors has gradually broadened. This has been due to the gradual withdrawal of the Chinese state from the economic and social sphere and its growing interest in transferring tasks to non-governmental actors (Lu 2005, 2). The central government has realized the great potential of non-governmental actors in distributing information and raising awareness of EEB and has conceded them relative freedom to unfold their actions on this topic. Nevertheless, as will be discussed further in the following sub-chapters, non-governmental actors' still face restrictions from the government which can limit their potential contributions.

1) Media coverage of EEB

The media is the most important actor when it comes to disseminating information and providing knowledge on energy efficiency issues to the general public. According to the great attention the government has put on enhancing energy efficiency in its 11th Five-Year Plan since 2006, energy politics and policies have become an important and increasingly covered issue in the Chinese media. This trend also applies to the topic of EEB, whose coverage has been growing only recently.[18]

However, information provided by the media about EEB is still not sufficient and not specific enough. Apart from specialized newspapers, e.g. *urbane*[19], the media has not yet considered EEB as being an important issue and still devotes little attention to covering EEB issues (Liang et al. 2007, 1105). In addition, media coverage rather focuses on public policies instead of providing concrete information to consumers on the co-benefits, technical measures and options of enhancing EEB through energy saving behavior. There was far-reaching agreement among interview partners from NGOs and the media that the low quantity and quality of EEB media coverage is due to two main reasons: first, the lack of capacities among journalists to cover complex EEB issues and second, the low publicity effect of the issue.

2) NGOs as a driving force to raise awareness of EEB

Recently, Chinese NGOs have shifted their attention from traditional environmental issues to climate change and energy. Some NGOs have therefore introduced special working units on the topic. NGOs active in the field of EEB have played a prominent role in advocating energy saving behavior through public campaigns and have begun to make an impact on government policy and practice. In the field of EEB, NGOs act as public

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18 Results were derived from two sources: first, the perception of our interview partners and second, from a media analysis of energy related articles published in China Daily and Shanghai Daily between December 2004 and March 2008.

19 *urbane* is an English-language monthly magazine devoted to architecture, design, lifestyle, travel and real estate.

awareness builders, agenda setters as well as technical experts and also fulfill operational functions through the implementation of EEB pilot projects.

Among the most well known Chinese environmental NGOs, which engage in EEB related issues, are Friends of Nature (FoN), Global Village Beijing (GVB) and Green Earth Volunteers, all located in Beijing. In addition, internationally operating organizations such as the World Wide Fund for Nature (WWF) have been driving forces to set EEB on the public agenda.

Even though the scope of action of environmental NGOs in China has broadened since the 1990s, NGOs still face some restrictions which can limit their potential contribution to the successful implementation of EEB policies and measures. On the one hand, according to statements made by NGOs activists, journalists and international experts, limited financial and human resources, including a lack of knowledge of EEB among NGO activists, constrain the organizations' capacities for action. On the other hand, the room for maneuver of NGOs in China is defined by governmental registration and monitoring mechanisms, which limit membership, regional and thematic expansion of NGOs (Lu 2005). Regarding the impact of these restrictions on NGOs working on EEB, we observed that only big and often international operating NGOs located in Beijing and Shanghai engage in EEB-related issues and concentrate their actions on the two metropolises, which limit their potential impact on the broad mass of Chinese citizens.

NGO activities on EEB can be mainly observed in three interrelated fields: a) awareness raising campaigns, b) policy advice and capacity building as well as c) demonstration projects. In the following, some prominent examples of successful NGO actions on EEB in the three fields will be given.

a) Awareness-raising campaigns

The "26 °C Campaign" has become a prominent example of the successful cooperation among NGOs to promote sustainable energy use in buildings. In 2004, six environmental organizations in Beijing jointly launched the "26 °C Campaign". The campaign aimed at urging institutions throughout Beijing to save energy and protect the environment by setting their air conditioners at 26 ºC or above in summer. The "26 °C Campaign" received the support and cooperation of over thirty environmental organizations throughout China and various five as well as four-star hotels in Beijing. In addition, a public office building and embassies also committed themselves to the campaign's goal (GVB 2007). Even though the campaign was targeted at public and commercial buildings, through its intensive publicity work it also aimed at raising awareness among the general public about sustainable energy use in buildings.

Since January 2007, the WWF, in cooperation with a wide range of governmental and non-governmental actors, has been undertaking the large scale "20 ways to 20 %" energy efficiency campaign, which aims at supporting the achievement of the 20 % efficiency target set in the 11th Five-Year Plan. Through training, public speeches, efficiency competitions, and other activities an attempt is being made to raise public awareness and the extensive engagement of the public in energy saving is being promoted. Core of the campaign is the "Cool Energy Hero" (20 ways to 20 % Campaign 2008).[20]

b) Policy advice and capacity building

Through public campaigns, policy advice and the organization of workshops NGOs have successfully contributed to the development of new EBB policy measures and instruments. Two examples are listed below:

- Air Conditioner Energy Efficiency Standard, 2000: The WWF China gave policy advice to government agencies in the process of renewing the Air Conditioner Energy Efficiency Standard (WWF 2007).
- Renewed Energy Conservation Law (Art. 33), 2007: The "26 °C Campaign" successfully influenced the adoption of a new policy by the national government, which stipulates that air conditioners in public buildings are set at 26 °C or above in summer and below 20 °C in winter.

Furthermore, Chinese NGOs have engaged in capacity building programs for NGO activists and journalists.

20 Website of the "20 ways to 20%" Energy Efficiency Campaign: www.20to20.org

c) Demonstration projects

Big NGOs such as the WWF have also initiated demonstration projects to support EEB. The Low Carbon City Initiative of the WWF aims to improve energy efficiency, amongst other things, in the construction sector by exploring low carbon development models in different cities. Within the initiative the WWF has set up an eco-building demonstration project in Shanghai, which focuses on the development of systematic management methods of energy efficient buildings, such as an energy consumption statistic, a disclosure system and energy audits (Yong Yi 2008).

3) Companies

Just within the last years, national and international companies have discovered the great potential inherent in the formation of a new market for energy efficient building solutions and technologies in China. However, companies still face constraints when trying to enter the market such as the intransparency of the Chinese housing construction market, a lack of knowledge about products and amongst building professionals themselves as well as, in general, lacking public knowledge and awareness that inhibit the demand for energy efficient building features. In response to those challenges companies and business associations have actively engaged in the dissemination of information about EEB using the same instruments as NGOs, e.g. demonstration projects, training and capacity building as well as awareness raising campaigns.

In order to better position international companies and bring best practices and EEB products to China, new business associations have just recently been formed. While these associations aim at facilitating the market entry of their members, they primarily do so by engaging in informational measures on EEB. The following gives a short overview of three of these business associations:

> *"The MOC [now MOHURD], for example, needs software which helps to submit documents for the building application. Suppliers need to know where to buy insulation. Contractors need to know how to install insulation. Buyers need to understand why they should invest in green buildings. Real estate agents need to know how to sell green buildings. It is all about information. We need to educate the people."*
> (Business association, Shanghai)

- Econet China: Information, networking and marketing platform for building, energy and environment set up in January 2008 by the German Chamber of Industry and Commerce Shanghai (www.econet-china.com).
- ETICS Quality Alliance: An association of European companies involved in External Thermal Insulation Composite Systems (ETICS), launched in March 2008 under the leadership of the Delegation of the German Chamber of Industry and Commerce Beijing.
- JUCCCE: The Joint U.S.-China Cooperation on Clean Energy (JUCCCE), founded in July 2007, acts as a hub for industry and governments to bring best practices and products to China's key decision makers (www.juccce.com).

5.4 The impact of Chinese culture, lifestyle and behavior on EEB

The adoption of energy-saving behavior, meaning the efficient use of energy and the choice of energy efficient building features and appliances, is a difficult and long-lasting process because it requires widespread changes in individual habits. Cultural factors and changing lifestyle patterns may influence the purchase of EEB products and energy saving behavior. Therefore, lifestyle aspects, cultural aspects and energy behavior are important determinants to hamper and advance the successful implementation of EEB policies in China and will be discussed in the following sub-chapters.

5.4.1 Lifestyle aspects

The rapid economic growth of China in the recent decades has changed consumption patterns and lifestyles of the Chinese population. It has led to an overall increase in energy consumption (Austin 2005). We identified three main lifestyle aspects which influence the implementation of EEB policies and measures: 1) private home ownership and apartment size as an economic status symbol, 2) little experience of residents with living comfort and 3) a short-term planning horizon.

1) Private home ownership and apartment size as an economic status symbol

We observed that in China private home ownership and the size of the apartment has become an economic status symbol. There was a strong consensus among all interview partners that every Chinese household aspires to buy an apartment. In addition, we found that small apartments are perceived as a symbol of former hard times, leading to the aspiration to buy bigger and bigger apartments even if the household does not necessarily need the amount of living space that is provided by the new apartment. Consequently, this leads to a high demand for big apartments and growing living space per person, which has a negative impact on energy consumption.

2) Little experience of residents with living comfort

Various German architects see a major barrier for the demand of energy efficient buildings due to the fact that the majority of people in China have not experienced living comfort as yet. They express their concern that people's awareness is not able to keep pace with the economic growth and the construction of new buildings in China in the last 20 years. As the majority of people have been used to a more simple life, they are already satisfied with the improved living standards they have achieved by moving into a new building. Consequently, many people still do not possess the experience of living in comfort and do not demand high quality building features, including EEB.

3) Short-term planning horizon

As a cross-cutting issue we noticed a short-term planning horizon along the actors chain, which proves to be a strong disincentive for EEB investments. Our interview partners often related the short-term planning horizon to the fast economic growth in China.

On the household level, it has become fashionable to frequently sell apartments every couple of years in order to buy a

> *"In the last few years many things changed. Ten years ago people lived in an apartment their whole life, but nowadays we move into a new apartment every 10 years or less."*
> (Household, Beijing)

bigger and newer apartment. This practice has been encouraged by the constantly rising prices for apartments in the last years, since people can sell their old apartment for a higher price than they have paid for it and invest the money in a newly built apartment. This practice seems to be a disincentive for households to invest in energy efficient building measures, which are only paid back in the long run. In addition, some interview partners expressed their concern that the short-term planning horizon of Chinese households also keeps people from purchasing energy efficient appliances.

5.4.2 Cultural aspects

Heating and cooling are not only a technological issue but also a cultural institution, shaped by patterns of human activity and the symbolic structures that give such activities significance. Another cross-cutting issue we noticed was that interview partners often attributed the Chinese government as playing a strong role and delegated the main responsibility with regard to enhancing EEB to the state, both impeding EEB investments and the energy efficient behavior of households. We identified two factors that could explain this notion and the specific impacts on EEB: 1) the legacy of the social welfare system provided by the state prior to the reform period and 2) the top-down approach of politics in China.

1) Legacy of social welfare system prior to reform period

During the first decades after World War II, the social welfare provision in China was organized by work units (*danweis*). Central characteristic of the *danwei* was the unity of living and working space. In urban areas, the work unit assigned living quarters to individuals and took care of their energy costs. In addition, *danweis* provided social benefits such as pensions, basic education, healthcare, childcare and recreation facilities. Thus, *danweis* functioned as *"mini-welfare states"* (Lindbeck 2006).

Economic reforms, in particular the privatization of state-owned enterprises, have rendered these social arrangements dysfunctional. Since the commercialization of the housing sector, about half of the houses have been sold to individual families and a market for real estate has developed. While occupied homes were sold to employees of state enterprises at discount prices, new houses are generally sold by housing developers at market prices (World Bank 2001). Today, only universities and other state institutions function as a *danwei* and provide subsidized housing and heating for their employees.

Due to the fact that people in urban areas in China have been used to this extensive system of social welfare provision, they still award a strong role to the state when it comes to taking care of the provision of housing and energy. This has two effects on EEB. First, state subsidies for energy are considered as being a social right of the citizens; and second, the main responsibility for retrofitting is delegated to the state.

2) Political top-down approach

In contrast to Germany where environmental protection, including energy saving, has been advocated by a broad environmental movement since the 1970s, international interview partners perceived environmental protection efforts in China mainly as a political top-down process. We observed (potentially) positive as well as negative impacts of this approach on the implementation of EEB policies and measures.

On the one hand, a recent study by the CASS (Chen et al.) shows that Chinese college and university students think the government should play the key role in energy saving and environmental protection, instead of linking the enhancement of energy efficiency to their own behavior. This notion was confirmed by our own interviews. The tendency to delegate the main responsibility of enhancing energy efficiency to the government acts as an obstacle for EEB investments and does not encourage energy saving behavior.

On the other hand, some Chinese interview partners found it to be their citizens' duty to save energy and would do so for this reason, even though they were not completely sure of the benefits of their behavior. While it would surely be more desirable that people completely understand the impact of their behavior and act energy efficiently according to their knowledge and awareness of the issue, this sense of duty can still serve as an important lever in order to improve EEB in China.

5.4.3 Energy behavior

Patterns of behavior may increase or decrease levels of energy use to the same extent that the choice of appliances does. On the one hand, it is important to identify factors that influence the decision to buy energy efficient appliances and, on the other hand, it is crucial to identify behavioral patterns that are efficient and also those that need to be improved with regard to energy conservation. The following sub-chapter will therefore focus on two aspects of energy behavior: the purchase of energy efficient apartments and appliances as well as the usage patterns with regard to energy.

1) Purchase of energy efficient apartments and appliances

Whether consumers purchase energy efficient apartments and appliances depends on a variety of factors, such as information/awareness and costs. To understand if energy efficiency has an influence on the purchasing decision of consumers in China, we will concentrate on two aspects: Do consumers in China consider energy efficiency when they buy a) an apartment or b) electric appliances, i.e. air conditioners?

a) Purchasing energy efficient apartments

In accordance with other surveys (Glicksman / Norford / Greden 2001), we found that consumers show almost no preference for energy efficient buildings. When purchasing an apartment, the most important selection criteria are price and location (close to their place of work, city center or school).

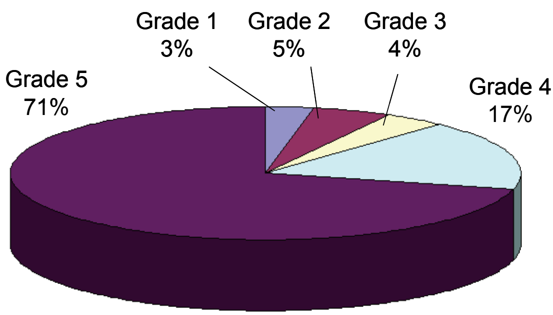
b) Purchasing energy efficient air conditioners

In China, consumers' preference for energy efficient air conditioners is still low. Assessments of China National Institute of Standardization (CNIS) (IEA 2007a) show that in 2005 the products with energy efficiency ranks 1

> *"My biggest concern right now is figuring out how to improve energy-saving awareness among residents, who care only about price and location when they buy apartments."*
>
> (Qui Baoxing, Vice Minister of MOHURD 2008, source: Econet China 2008c)

and 2 have an approximately eight percent share of the room air conditioner market. In contrast, the products with energy efficiency rank 5 have a market share of 71 percent. Therefore, most air conditioners are sold with the lowest energy efficiency level (see Figure 3).

Figure 5: Composition of sales of air conditioners by energy efficiency in Chinese markets 2005



Source: CNIS 2005 in: IEA 2007a

2) Use of energy

Until now, only few data exist about the nature and type of energy use within individual urban households in China. Nevertheless, based on some studies (Zhang 2004, Long / Zhong / Zhang 2004, Brockett et al. 2002) and our own field research, this chapter aims to identify heating and cooling habits as well as motivational factors which increase and decrease the energy consumption of households in Beijing/Tangshan and Shanghai. In China, residential energy consumption depends strongly on the climate zone as well as the heat metering and payment system (Zhang 2004; Brockett et al. 2002). Therefore, heating and cooling behavior in Beijing/Tangshan and Shanghai will be treated separately in this chapter.

a) Heating and cooling behavior in Beijing and Tangshan

In Beijing winters are long and cold, typically coldest from November to February, while summers are short and hot (Brockett et al. 2002, 8.30). Beijing lies within the area of China's traditional central heating zone. Due to the central heating supply, households rarely use electricity for heating in Beijing/Tangshan. In winter, residents living on the upper floors often perceive the indoor climate of their apartments as being too hot, while residents living on the lower floors perceive it as being too cold. The absence of individual heat regulators encourages energy consumption and it is very common behavior to open windows in the case of rooms being overheated.

Beijing/Tangshan residents told us, that they only use the air conditioner on very hot summer days. Many residents said that they prefer to use a ventilator rather than an air conditioner because it costs them less, it is better for their health and they are able to open the windows whilst using the cooling device.

The use of insulation and double-glazed windows is also more common in the colder northern cities. According to a study by Brockett et al. in 2002, 30 percent of the surveyed households in Beijing used insulation and an additional 16 percent insulated only the north-facing walls. In Shanghai insulation use was as low as two percent (see Table 2).

In the colder regions of China, it is a common practice to enclose balconies with permanent windows to expand the living space in the heating season and have additional space for drying clothes. In Beijing, 97 percent of the surveyed households by Brockett et al. had enclosed balconies, while in Shanghai it was almost 20 percent less (see Table 2).

The practice of enclosing balconies can lead to an impaired use of energy for cooling in summer as an enclosed balcony restricts shading as well as

Table 2: Housing features in Beijing and Shanghai 1999

	Beijing	Shanghai
Insulation	46 %	2 %
Enclosed balconies (percentage of all balconied homes)	97 %	79 %
Single pane glass window	68 %	98 %
Metal window mounts	78 %	62 %

Source: Brockett et al. (2002)

airflow and traps a certain amount of incident solar radiation (Glicksman / Norford / Greden 2001).

b) Heating and cooling behavior in Shanghai

The climate in Shanghai is characterized by milder and shorter winters than in Beijing, which are coldest in December and January. Nevertheless, in total, there are around 109 days a year when the mean daily temperature is lower than 8°C (Long / Zhong / Zhang 2004). Summers are hot and humid (Brockett et al. 2002). In Shanghai there is no provision of a central heating system.

According to a survey by in 2001/2002, the spread of residential air conditioners in Shanghai had reached almost 100 percent. About 40 percent of the households owned only one air conditioner, which served one of several rooms and another 40 percent owned two air conditioners. Given the above described climate and heating system characteristics, Shanghai room temperatures in winter are usually below the comfortable level (Zhang 2004, 1224). In 2001/2002 around 67 percent of households in Shanghai used the air conditioner for heating for an average of three hours a day, while another 33 percent basically never turned on the air conditioner in winter. In summer, air conditioners were operated on average six hours long (see Table 3). According to Long / Zhong / Zhang, the main reason for this low usage percentage is the high cost of electricity with respect to income. On average, about 30 percent of the electricity bill of a family is spent on air conditioning. Compared to the US, which on average has about the same number of heating days as China, the usage ratio of air conditioners in Shanghai is still quite low (Zhang 2004).

In the household interviews we conducted during our field research in Shanghai, residents named several measures they undertake to save energy and costs such as: turning off the air conditioner when leaving the room, using the air conditioner only in one room, operating the air conditioner only in the morning and evening/night hours. Further measures included using a time switch at night, all of the family members sleeping together in one air conditioned room, turning the air conditioner in summer to 26 °C or above and wearing additional warmer clothes in winter in order to cope with the low indoor temperatures.

Table 3: Usage of air conditioners (ACs) in Shanghai families		
Conditions for the operation of ACs	%	Estimated average operating hours per day
Summer		
Basically never turned on	3.7	6 hours
Turned on once occupied	6.7	
Turned on when feeling a little hot	35.5	
Turned on when feeling hot	54.1	
Winter		
Basically never turned on	32.7	3 hours
Turned on once occupied	2.9	
Turned on when feeling a little bit cold	18.8	
Turned on when feeling cold	45.6	
Source: Long / Zhong / Zhang (2004)		

5.5 The value chain of the Chinese housing sector

Apart from the problems that arise from the political and economic structures as well as informational and cultural conditions, the value chain in the Chinese housing sector itself educes critical aspects leading to implementation problems. It is very complex and depends on the effective interplay of the actors. However, this often does not occur as one can see from our research in the following chapter.

With respect to energy efficiency, the two sub-sectors of the Chinese housing sector, the construction sector on the one hand and the existing residential building sector on the other, face different challenges and possibilities. Even though some actors such as architects or local governments are identical, their roles are very different within the two sectors as these feature entirely different actor constellations. In the following, the specific actor constellations and challenges for enhancing energy efficiency in new and existing buildings are analyzed.

5.5.1 New buildings: The housing construction sector

The value chain in China's construction sector is quite linear but a diversity of actors participate. We can identify a number of structural barriers that obstruct the effective functioning of the value chain. It is striking that in addition to linking problems, the major shortcomings within the value chain are the lack of know-how of as well as communication between the different actors. Quality - often stressed as a key problem - appears to be less relevant.

1) Links in the complex value chain

There are two critical links arising from the value chain within the Chinese construction sector: a) The link between local governments and developers, and b) the link between architects and design institutes.

a) Local governments and developers

The local governments usually sell land use rights to a developer. At least two obstacles for the successful implementation of EEB policies arise due to this connection:

- Local governments often limit the supply of land use rights which forces developers to pay higher prices. Through this, local governments can realize enormous profit margins from the transactions which in turn leads to a sharp rise in housing prices which then decreases the budget for EEB investments.
- The good relationship between developers and the local government is a precondition for developers to operate, as interviewed architects confirm. This seems to be a very high hurdle to pass before entering the market as the number of developers in the Chinese residential market is limited when compared to the huge number of contractors competing for assignments. The oligopolistic market structure may be one reason for the central role that the developers play in the construction process. Therefore, the small number of developers has the power to choose the architect and the contractor; these, in turn,

often offer their service at a low price. Additionally, architects often feel that they are not in the position to give advice to the developer.

b) Architects and design institutes

Architects, working independently or in the state design institutes, conduct the building design while technical planners in the design institutes take care of the more detailed technical planning. Architects affirmed that the separation of responsibilities and the lack of communication lead to an enormous loss in efficiency. With regard to EEB, the problems that arise from this are twofold:

- The architects tend to neglect EEB in the design phase and count on the technical planners to add the details later. However, some EEB products need to be taken into account in the initial design phase if they are to unfold their whole future potential. Otherwise wrong performance calculations or simple limitations in space can prevent energy efficient material from being correctly applied.
- According to architects working in Beijing, design institutes adhere much too much to their books that contain the technical details and specifications. They generally refrain from developing solutions that can be adapted to the respective building but instead resort to the content of the available design books. These often do not reflect the "state of the art". Even though the books are frequently revised they still lack some energy efficiency measures that are already common in European countries. In consequence, if an architectural design contains new measures in order to enhance EEB, these will not be applied by the design institute as long as these cannot be found in the books.

2) Technical know-how on EEB

The demand for new EEB technology in China is very small. In the interviews architects stated that most of the developers who select the materials are insufficiently skilled in architectural design and choose the materials that have the lowest costs. Again, the allocation of responsibility in the current value chain obstructs architectural influence on material producers.

Not only the developers are unskilled regarding EEB technology. Both architects and workers also lack expertise. Technical know-how of building professionals at all links of the value chain is a prerequisite for the construction of an energy efficient building.

The lacking know-how of construction workers and the missing training initiatives are crucial shortcomings within the building sector. The construction workers usually worked as farmers before they were recruited and do not have any experience in the application of technology.[21] The lack of training can mainly be traced back to lacking incentives among developers, the building material industry and construction companies. Construction workers circulate too frequently between the construction sites. This makes it difficult for providers of training measures to receive a benefit from training workers.

There is also a lack of knowledge on EEB among architects. Studies show that architects do not consider energy consumption as being a pressing issue and are therefore not concerned about the design of energy efficient buildings (Lo / Zhao / Cheng 2006, 1330). Energy efficiency does not form part of the curricula of architectural schools in universities. Even the most renowned schools in this field only provide a very limited number of courses on EEB. This causes some developers to employ architects from abroad who have the necessary expertise to apply EEB technologies. However, the MOHURD is trying to increase architects' awareness of energy conservation codes by distributing a monthly newsletter to licensed architects and by requiring that all licensed architects within the heating zone area pass an exam on the building energy conservation standard (Glicksman / Norford / Greden 2001, 98).

Both developers and the building material industry react in different ways to this challenge depending on the market segment they are active in. Mass-market developers are not particularly challenged by the limited know-how of architects and construction workers, as quality and the expected life span of a building is not part of the consumers' buying decision in this segment. The same applies for producers of low-cost, low-tech material. The situation turns out to be different for high-end

21 The lack of EEB-related expertise is a problem with regard to the application of both low-tech and high-tech material. Through incorrect application, efficiency losses can occur. Nevertheless, it is particularly challenging when high-end technology is applied to a building. These products require extremely precise application in order for them to unfold their potential.

developers as well as producers of high-tech material and appliances. Due to the higher prices, their products can only be sold if the quality is significantly higher when compared to the mass market. A representative of a developer told us that it is common that high-end developers assign contractors to train the construction workers in the application of the technology that is used on the site. In addition, special quality management units are engaged to assure the correct application. Some building material producers stated that they provide training for architects and engineers working in design institutes in order to get their products applied in a correct manner. These are examples for market-driven efforts to improve the skills of building professionals. However, they are only valid for the high-end market segment.

3) Quality of EEB technology

Despite the structural barriers that hinder further technology development, the quality of Chinese EEB products is sufficient so that they can be used broadly in the residential sector. Most of the imported technology has been sufficiently adapted to Chinese conditions. The chief engineer of a developer stated that the predominant strategy of Chinese producers is the "localization" of foreign-developed technologies. This means that foreign technologies are adopted and adapted to local conditions in order to manufacture the products locally instead of importing them. Research and development in its genuine sense is the technological base for only one-third of the products that are available in China (Liang et al. 2007, 1103). Due to the practice of "localization", it is important to keep in mind that when the terms "Chinese" or "imported" are used, this often does not refer to the product itself but only to the technology it is based on.

Although the quality of EEB products manufactured in China is sufficient to be employed broadly, it is still lagging behind the European level. Air conditioners, for example, still have relatively low efficiency rates when compared to European products (IEA 2007b, 383). High-tech material still has to be imported and is not available at prices suitable for non-luxury housing (Glicksman / Norford / Greden 2001, 99). However, it seems convincing that high-tech is not suitable to be widely used as long as the education of construction workers is limited. As shown earlier in this report, the potential advantage that high-tech material disposes of can completely be annihilated by the incorrect application by the unskilled workforce or the inadequate application by technical planners. For these reasons it can be stated that, currently, low-tech material is better adapted to the mass market than high-end products.

5.5.2 Old buildings: challenges for retrofitting

Compared with the housing construction sector, a linear value chain cannot be identified as clearly with regard to retrofitting. This is due to the fact that unlike in the housing construction sector, so far, there are no established and universally applied procedures for retrofitting. This implies that different tasks can potentially be fulfilled by a variety of actors. In addition, in the case of retrofitting the value chain and its unclear organization induces challenges which will be discussed as follows. Numerous insights which we gained in this context are based on the research we conducted on retrofitting projects such as the GTZ pilot project in the city of Tangshan.

1) Initial action and the role of local governments

The first step with respect to retrofitting is to initiate the complex and protracted process. The key question in this context is: Who takes the initiative? Various stakeholders can potentially trigger the process by trying to raise the topic with a municipality and put it on its agenda. In Beijing, there have been cases of resident groups which were formed and then put pressure on the local government as well as heat providers to raise their room temperatures and thereby, for example, improve the overall room climate. However, since this takes quite a high degree of auto-organization, in most cases local governments are the driving force behind retrofitting and not the residents.

GTZ's Tangshan project shows that, apart from initiating the retrofitting process and financing a big share of it, there are also other reasons why the local government plays a leading role. As retrofitting in Tangshan involved a plurality of governmental departments such as the construction department, planning department, municipal management department, housing management department and power supply department, the local government had an important role as coordinator (Sino-German Technical Cooperation "Chinese Energy Efficiency in Existing Buildings" Project 2007).

2) Discomfort for residents

Retrofitting is a time-consuming undertaking which brings a great amount of discomfort for residents. During the construction phase, the residents' every-day lives can be disrupted by noise, dirt and the presence of workers.

Therefore, it has proved to be easiest to conduct retrofitting in lower-income apartments where there is no risk of damaging valuable furniture or interior decoration and residents are less reluctant to allow work to take place. One option (that was also adopted in the GTZ project in Tangshan) which makes residents more ready to accept work being carried out in their private living area is to adopt an integrated approach, i.e. to combine energetic retrofitting with a general renovation of the apartment, carrying out different tasks in one go.

3) Collective action and the decision-making procedure

China has one of the highest home ownership rates in the world, largely as a result of the privatization of public sector housing (Duda / Zhang / Dong 2005, 8). About 50-60 percent of Chinese urban families own their apartments (World Bank 2001, 10). As most apartments are individually owned, residents themselves can only renovate the portions belonging to them, so the external wall insulation, roof heat insulation and heating system renovation need to be collectively organized. This implies that all of the inhabitants of a house need to agree on the carrying out of the retrofitting work and must be willing to make the necessary contribution. Transaction costs are generally high due to the great number of people involved and a lot of advocacy work on the part of the local government and, for example, the international development cooperation agencies is necessary in order to educate residents about the benefits of retrofitting. To be able to count on the cooperation of resident committees is essential in this context.

In order to better illustrate the benefits to residents, successful examples of retrofitting projects have a convincing effect. In Beijing, for example, residents agreed that their house should be retrofitted after they had visited the GTZ project in the nearby city of Tangshan. Research by MOHURD found that 68 percent of Beijing residents said that they would pay more for enhancing EEB after visiting the site of the project in Tangshan.

Before visiting, just 30 percent had said that they would pay extra (China Daily 2008).

4) Costs and cost-sharing

Retrofitting old buildings is expensive when compared to enhancing energy efficiency in new buildings. In Tangshan, the total costs (including extra or additional costs) were shared by the stakeholders as follows: government: 53 percent, Sino-German EEEB Project (international cooperation): 25 percent, heat supplier: 11 percent, residents: 6 percent and social donations: 5 percent (Sino-German Technical Cooperation "Chinese Energy Efficiency in Existing Buildings" Project 2007, 97). In the case of Tangshan, no ESCO took on a part of the costs, nor were private investors of the voluntary carbon market involved.

Given that the Tangshan project is a demonstration project, this allocation formula for burden sharing can hardly be generally applied. Therefore, it remains an open question as to how the costs of retrofitting should be distributed among the different stakeholders, i.e. residents, heat-providers, the government at the local as well as central level and the state-run companies which used to own the apartments. To date, there are no legally binding regulations which prescribe how costs are to be shared.

In most cases, the inhabitants of apartments in need of retrofitting are unable to pay for the entire retrofitting costs. Additionally, most residents will not agree to carry the whole burden of improving the apartments which were originally constructed by the government. For them, it is obvious that, as the constructor and former owner, the state has a major responsibility to make a financial contribution.

For the MOHURD and local governments, it is a huge challenge to find out what an ideal sharing of the financial burden could look like. On the one hand, residents are supposed to contribute, but on the other hand they will not agree to an arrangement which they perceive to be unjust. Consequently, in each municipality, an individual and specific balance of interests has to be found by means of institutionalizing a participative communication process which involves all stakeholders (Sino-German Technical Cooperation "Chinese Energy Efficiency in Existing Buildings" Project 2007, 148).

6 Main findings and recommendations

6.1 Main findings

EEB is a highly relevant issue in China. The aim to reduce energy intensity in the construction sector is being forcefully supported from the political side and is imperatively needed. However, the implementation of EEB policies and measures is a difficult and complex process which is influenced by structural determinants and actors alike. Different factors, which manifest themselves mainly in the political as well as economic field and are intensified by informational deficits, cultural specifications and the actors' constellation, lead to an implementation gap.

Politically it is obvious that the legal system and enforcement issues constitute a major barrier. Weak monitoring mechanisms due to the lack of financial and human resources as well as the prioritization of economic interests are the main reasons that existing regulation are not implemented. Apart from the enforcement deficits, economic incentives to invest and apply EEB are missing. Price distorting subsidies for energy and the heat billing and metering system in Northern China support the maintenance of the status quo. Due to asymmetric information, consumers are not able to evaluate the quality of EEB and are reluctant to invest in EEB. Furthermore, a lack of capital prevents investments in retrofitting.

Information deficits, cultural specifications and the constellation of actors are cross-cutting factors. They pre-impact the structural conditions within the political and economical field. The main informational barrier here is the lack of knowledge and awareness of the benefit and co-benefits of EEB, i.e. the monetary-saving potential and improved living comfort as well as technical measures and options to enhance EEB, among the general public, NGOs and the media. Concerning lifestyle and culture, it is obvious that the role of private home ownership and the size of the apartment as a status symbol in addition to the residents' limited experience with living comfort negatively influence the implementation process. Finally, the actor and value chain is characterized by missing effective links and by communication problems as well as the lack of technical know-how among building professionals.

6.2 Recommendations

Clearly, there are no easy answers to the question of how the implementation of policies can be improved. We have formulated recommendations for the fields that we investigated. As the fields are closely linked, the recommendations need to be regarded as a whole, mutually supporting and complementing each other. There exist different degrees of interdependence between the recommendations, with some forming the basis for the implementation of others and some having the potential to have an impact, even if this is on an independent level. Therefore, a pragmatic approach should be adopted. Instead of attempting to realize the recommendations as a whole, they should be implemented successively.

The aim of the following chapter is to present recommendations for various actor groups on how to improve the implementation of EEB policies and measures in the different fields. As we devised the recommendations based on the results of our analysis in chapter 5, they address the problems regarding the legal system and enforcement, economic incentives, awareness raising and capacity building as well as the housing construction sector.

Legal system and enforcement

So far, monitoring rarely takes place. It is important that the Chinese government strengthens the existing systems for monitoring the implementation of building standards in order to counteract the existing culture of non-compliance. Strengthening the existing monitoring systems can be achieved by increasing the quantity and quality of monitoring, gradually involving private agencies and improving the institutional setting.

The quantity and quality of monitoring can be increased by a higher number of samples in the form of unannounced inspections and the number of inspectors being deployed. At the same time, training measures for inspectors have to be enhanced. To ensure high quality inspection, fixed criteria and working procedures need to be developed for all inspections. A province rotating system for inspectors, changing their field of responsibility every two or three years may help to prevent bribery. Finally, it has to be ensured that penalties for non-compliance are de facto enforced.

The involvement of private, independent institutions can also improve the quality of inspections. Therefore, a greater number of monitoring jobs should be transferred to independent private agencies which are not involved in the construction sector's value chain. Furthermore, an award system remunerating private agencies which detect non-compliance sets incentives for controls. However, the private agencies' work and objectiveness should be controlled, e.g. through the newly established China Green Building Council.

To also support the monitoring system on the national level, monitoring should be institutionalized in the form of a permanent organization (e.g. the Specialized National Inspection on Building Energy Efficiency or the planned China Green Building Council) in order to receive proper support with regard to the monitoring process. Nevertheless, enhanced cooperation between national monitoring institutions and the local monitoring agencies is necessary.

Economic incentives

First of all, it is clear that the Chinese government needs to increase the energy prices in the long-run. Although subsidies have been reduced, the prices for energy are still distorted and do not reflect the market prices. Only if consumers pay the real price and only if they are able to benefit from energy savings do they have incentives to invest in EEB. However, social aspects have to be considered in the formulation of new tariff systems to ensure that lower-income families have access to energy.

The market transparency can be improved by the establishment of online product databases to make the prices and the availability of energy efficient building products more transparent. The government and business associations should push forward the development of certification and labeling systems for energy efficient building materials and appliances to increase public awareness as well as the transparency regarding quality. Another option to contribute to transparency is the enhanced and mandatory application of labeling systems for energy efficient buildings. The China Green Building Council can play an important role and could provide management and quality control methods as well as technical guidelines. Furthermore, the government should include the energy consumption of single apartments as a component within its Building

Energy Efficiency Label in order to make the energy consumption of apartments more transparent to potential home buyers.

Funding of EEB investments is also a key issue. New and accessible funding schemes for EEB investments need to be introduced. The central and local governments should jointly push forward the implementation of new economic instruments such as tax cuts, subsidies and preferential loans for developers and households (i.e. microcredit schemes) to make EEB investments more attractive, broaden its distribution and to promote the development of an EEB market. Furthermore, the local governments should reinvest a part of the high revenues generated by land sales to support EEB funding schemes.

In addition to the traditional funding schemes, alternative sources should be explored. The government and international cooperation agencies should look at the use of alternative financing schemes for EEB in general and retrofitting in particular, such as the Clean Development Mechanism or the voluntary carbon market. Also, the use of private-public partnerships and Energy Service Companies should be promoted within this context. In general, funding systems should be made more transparent and information on economic instruments spread to the target groups so that developers and households can easily access the funds.

Compared to new buildings, the retrofitting of existing buildings faces different challenges. National and local governments as well as international cooperation agencies should promote retrofitting of existing buildings in order to create the basis for the implementation of the heat billing and metering system reform. By means of a participative communication process which involves all stakeholders, an individual solution for sharing the costs of retrofitting needs to be found in each community. For carrying out this process, best practices gained in projects already completed that take into account the residents' needs should be transferred to communities throughout the country via mayor platforms or other means of experience and knowledge exchange.

Awareness raising and capacity building

Awareness is essential and the precondition for investments in EEB and is therefore a cross-cutting issue. Since distributed information on and awareness of EEB is generally low, capacity building and raising awareness is required for the entire range of involved actors.

First of all, it is necessary to offer more intensive training programs on the implementation of standards for local government officials in order to raise their awareness of the importance and urgency of EEB. Examples are the inclusion of EEB in the curricula of the Communist Central Party School and the provision of workshops for government officials.

Training and capacity building is not only relevant for governmental staff but also for journalists and NGO activists in order to achieve a broad dissemination. The government, research institutes, international cooperation agencies and NGOs with experience in the field of EEB should convene workshops as well as forums for journalists and NGO activists on specific EEB issues to improve their knowledge and enable them to undertake activities and report on the topic. To enable Chinese NGOs to work on EEB, international NGOs and international cooperation agencies should aim at strengthening their financial and human resources by providing funding as well as fostering international and national networks for knowledge transfer and joint action.

The government, international cooperation agencies and business associations should promote the development of business networks, including architects which promote energy efficient buildings, share product information, develop case studies and facilitate networking and knowledge transfer between companies and different regions. One option would be to push forward the establishment of the China Green Building Council as a platform for networking and knowledge exchange for all governmental and non-governmental actors involved in EEB in China. This could also include different provinces and municipalities. Moreover, the awareness raising campaigns of the NGOs in China's urban centers on the east coast related to EEB can be expanded to NGOs throughout the country. This can be supported by a transfer of best practices from the established NGOs to smaller organizations.

At the end of the value chain is the consumer. Through their preferences and their buying-decision they have huge influence on market activities. In order to raise public awareness of the impact and importance of EEB, the government, NGOs, the media and business associations should launch broad information and education campaigns to inform on the benefit and co-benefits of EEB investments. Furthermore, information campaigns should provide concrete instructions on energy saving behavior and information about low-tech EEB products and initial investment costs. To increase energy saving behavior and raise public knowledge of the link between EEB and climate change, benefits and measures to enhance EEB should be included in all middle school curricula.

Furthermore, marketing campaigns by developers and real-estate agents should focus on the co-benefits of enhanced EEB, in particular improved living comfort, health and monetary saving potentials in order to increase consumer demand for energy efficient buildings.

The government should raise public awareness of the impact and importance of EEB by using the Building Energy Efficiency Label to document the energy performance of all public buildings and establishing positive examples of improved EEB in public buildings.

The housing construction sector

To overcome the major problems in the housing construction sector the communication among actors in the construction process and the technical know-how of architects and construction workers needs to be improved.

The regulation that splits the responsibility for design and technical planning should be abolished in order to establish a closer link between architectural design and the technical planning of buildings, which fosters knowledge transfer and innovation.

Training is an essential measure to guarantee the effective application of EEB technology. The government should create incentives for construction companies (subsidies or tax reductions) so that they train their construction workers or undertake these measures themselves. Furthermore, EEB-related training should be mandatory for architects. Energy efficiency topics should be included in the curricula at all universities that offer architectural courses. For architects that are already in business, it should be mandatory to attend training courses on EEB. Their license should be directly linked to these training courses. Students and active architects alike should be trained on how to incorporate energy efficient options in the early stages of a construction design in order to lower initial investment costs.

Glossary

Air conditioner

Air conditioning appliances are used to control the indoor temperature. Most of the appliances are constructed mainly for cooling but some can also be used for heating. Heating by use of electricity, however, is highly inefficient provided that the electricity does not stem from renewable energy sources. Air conditioners are available in different energy efficiency classes. Air conditioners used for houses and apartments have a coefficient of performance (COP) ranging from 2.2 to 3.8 in North America and Europe, and 4.5 to 6.2 in Japan. Chinese air conditioners at present have a COP of about 2.4, are thus less efficient than their Japanese, European or US counterparts (IEA 2007b, 276).

District heating system

District heating systems provide heat for a whole building compound or even parts of a city. They are common in Northern China. The heat is produced in a heat generation plant that is connected to a pipeline system. Through the pipelines hot water is channeled into the buildings. Modern systems dispose of three cycles that are linked within special stations. The first cycle flows through the heat plant, the second comprises the pipeline system and the third cycle flows through the buildings. In China, some systems only dispose of two cycles with the second one going directly from building to building, thus continuously loosing temperature and pressure.

Double-glazed window

The term “double-glazed” refers to the number of glass layers that are used in a certain type of window. Compared to single-layer windows, double-glazed windows offer the benefit of a better heat transfer coefficient (Ug). The Ug value displays the amount of energy passing through one square meter of glass in one second if the temperature differs by one degree Kelvin. Single-glazed windows usually dispose of a Ug value of 5.8 W/sqmK. Double-glazed windows are available in different versions. In many models, an air film between the two glass layers provides for a Ug value of 3.0. In Europe, so-called low-E windows are broadly available that dispose of a Ug value of 1.2 by using an inert gas between the layers.

Some passive houses even use triple-glazed windows with a heat transfer coefficient of 0.7. For all these measures it is important to use well isolated frames filled with a special insulation foam. Usually, these frames are made of a special plastic that has a lower heat transfer coefficient than e.g. aluminum frames.

Heat meter

Heat meters measure the amount of heat that is used in a specified space. There are different technical options to meter heat. Generally, a heat meter measures the amount of water that flows through the pipe and the difference in temperature before entering and after leaving the heating system of the specified space. Then, it calculates the amount of heat that was radiated. Heat meters can be used either for a single apartment or for a whole building. If the heat is metered for the whole building, so-called heat cost allocators that are installed at all radiators in the building can be used to calculate the share of heat consumed by every individual apartment.

Heating, Ventilation and Air Conditioning (HVAC)

In a broader sense, Heating, Ventilation and Air Conditioning (HVAC) comprises all factors directly linked to a building that actively influence the indoor temperature and air quality. Understood more narrowly, HVAC refers to systems that automatically keep temperatures and indoor air quality of large buildings at a constant level. HVAC systems can also limit air infiltration while providing ventilation and a regular air exchange. HVAC systems do not usually achieve high efficiency levels for residential buildings. Therefore, their use is limited to large commercial and public buildings.

One-pipe system

In a one-pipe system, all radiators in a building or in a building compound are connected in series. The heat leaving the first radiator moves on to the next. It is implicit to this system that radiators that are located at the end of the chain can only provide less heat than the first ones. Furthermore, the installation of flow valves to individually control the heat is not applicable.

Thermostatic valve

A thermostatic valve is used for the automatic provision of a constant room temperature. The desired temperature can be set at the valve.

Two-pipe system

In a two-pipe system, the heat cycle flows in an uninterrupted manner through the building. The heat provided by the radiators is constant within the whole building. A two-pipe system also allows one to completely turn off single radiators as the heat flow continues on in the second pipe.

Wall insulation

Up to 67 % of heating energy can be lost through an uninsulated façade (Hohenstein 2007, 6). However, in hot climates cool air also warms up unnecessarily if the walls are not insulated properly. Avoiding thermal bridges and direct thermal permeability of walls is therefore crucial in enhancing EEB. Many thermal bridges can easily be avoided by insulating the exterior surface of a building's external walls. The heat load can be reduced to 15–20 % in each case even if the insulation is only applied to the interior surface (Wang et al. 2004, 1293). Insulation of buildings can be undertaken with inorganic or organic (artificial or natural) materials (Hohenstein 2007, 13). The choice of material not only depends on the price but also on the thickness necessary to reach the highest efficiency level.

When space is the limiting variable, highly efficient insulating material is needed (IPCC 2007, 395). The European Low-Energy-House standard requires an insulation layer in the walls of at least 14cm (Gu 2007, 13). This might not be suitable for residential buildings in densely populated Chinese cities. It should, in any case, be taken into consideration that when using insulating foams that are blown with halocarbons, *"the benefit of reduced heating energy use can outweigh the effect of leakage of blowing agent when insulating buildings that were previously either poorly insulated or uninsulated"* (IPCC 2007, 406).

External Thermal Insulation Composite Systems (ETICS) are an opportunity to improve the thermal performance of both new and existing buildings. The system consists of insulating boards that allow for the application of plaster directly without any preparation of the surface being necessary.

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ANNEX

Table 4: Overview of all interviewed actors[1]		
Category	Interviewed institutions/organizations	Number of interviews
Government institutions		
City governments	Building authority Tangshan	1
	City government Tangshan, Energy Saving Office	1
	City government Beijing, Energy Conservation & Environmental Protection Centre	1
Ministry of Housing and Urban-Rural Development (MOHURD), Beijing	Department of Science & Technology, Division of Building Energy Efficiency and New Materials (separate interviews)	2
	Department of Heating Reform and Project Management of Energy Efficient Buildings (separate interviews)	2
	MOHURD representative at the Green Building Conference in Beijing, 2nd of April 2008	1
		8

1 In many cases we talked to two or more persons during one interview. This is indicated as one interview here. Some interview partners also covered different categories (e.g. an architect who works for a NGO concerned with green buildings at the same time). Those interview partners are only listed in the category which was the main focus of the interview. To some interview partners we talked twice.

Table 4: Overview of all interviewed actors (continued)		
Category	Interviewed institutions/organizations	Number of interviews
Academic experts		
	Chinese Academy of Social Sciences (CASS) in Beijing, Research Center for Sustainable Development (separate Interviews)	4
	Chinese Academy of Social Sciences (CASS) in Beijing, Center for Energy & Environmental Policy Research, Institute of Policy & Management	1
	Energy Research Institute (ERI), Beijing	1
	Tongji University Shanghai, HVAC Research Institute, College of Mechanical Engineering	1
	Shenzhen Institute for Building Research, Shenzhen	1
	Shanghai Institute for International Studies, Shanghai	1
	Fudan University, Shanghai	1
	Research Center of Building Energy & New Energy, Shanghai	1
	Shanghai Research Institute of Building Science (Department of New Building Technology; Shanghai Center of Research and Development (R&D) for Energy Efficiency in Buildings)	1

Table 4: Overview of all interviewed actors (continued)

Category	Interviewed institutions/organizations	Number of interviews
	Shanghai Academy of Social Sciences, Shanghai	2
		14
International cooperation		
	German Embassy, Beijing	1
	Heinrich-Böll-Foundation, Beijing	1
	Friedrich-Ebert-Foundation, Beijing	1
	GTZ, Beijing	2
	German Financial Cooperation (KfW), Beijing	1
	European Commission	1
		7
Companies		
	Dry Vit Systems Ltd. (US-company producing building insulation materials), Beijing	1
	ETICS Quality alliance (company networking platform of building material companies), Beijing	1
	Beijing Uni Construction Group Co. Ltd., Chinese heat provider (2 separate interviews)	2
	CAMCO Group (low carbon market company network), Beijing	1
	Vanke (Chinese developer)	1

Table 4: Overview of all interviewed actors (continued)		
Category	Interviewed institutions/organizations	Number of interviews
	JUCCCE (Joint US China Cooperation on Clean Energy; Company Network), Shanghai	1
	Minol (German heat meter company), Beijing	1
	Manitoba Hydro (Canadian Energy Company), Beijing	1
	Soben Board (Insulation material Company), Beijing	1
	Tsighua Air Conditioning (Chinese Air Conditioning Company), Beijing	1
	Shenzhen Coolead Industry Co. Ltd, (EEB service company), Shenzhen	1
	Chonqin Prior-V Group Energy Management Co., Ltd., Beijing	1
	Beijing Leye Energy Saving Company	1
	Fulcrum consulting (Consultant on Energy Efficiency and Sustainability)	1
	Econet China (2 separate Interviews)	2
	Shanghai Automotive Asset Management Co., Ltd. (SAIC), Shanghai	1
	Eco Tech. International Group	1
	Engelmann Heat Meter (Beijing) Co. Ltd. (German heat meter company)	1
		20

Table 4: Overview of all interviewed actors (continued)		
Category	Interviewed institutions/organizations	Number of interviews
NGOs		
	WWF Beijing	1
	WWF Shanghai	1
	Global Environmental Institute (GEI), Beijing	1
	Verein Stadtkultur International, Beijing	1
		4
Media		
	Science and Technology Daily (Chinese newspaper), Beijing	1
	Süddeutsche Zeitung, Shanghai	1
		2
German integrated experts (CIM)		
	China Environment & Sustainable Development Reference and Research Center (CESDRRC), Beijing	1
	Tsinghua University, Department of Environmental Science and Engineering	1
	CCHS Green Building Research Center (joint interview), also architects	1
	CANGO (NGO cooperation platform)	1
		4

Table 4: Overview of all interviewed actors (continued)		
Category	Interviewed institutions/organizations	Number of interviews
Building professionals		
	Beijing Institute of Architectural Design	1
	Moma Modern Group, Beijing	4
	Chinese Architecture Student, Shanghai	1
	Logon Architecture, Shanghai	1
	Jones Lang Lasalle (Real Estate Service Provider), Shanghai	1
	German architect specialized in energy and building services engineering, Beijing	1
		9
Households		
	Retrofitted building, Tangshan	1
	Non-retrofitted building in Tangshan	1
	Households with individual heating system in Beijing	2
	Households with central heating in Beijing	9
	Residents from Shanghai	3
		16

Table 4: Overview of all interviewed actors (continued)

Category	Interviewed institutions/organizations	Number of interviews
Others		
	Interpreter of the GTZ	1
	Urbn, a carbon-neutral hotel in Shanghai	1
	Counsel, Squire, Sanders & Dempsey L.L.P., Environmental Lawyer in Shanghai	1
		3
Total interviews		87

Table 5: Research focus regarding EEB		
Category	Possible units of analysis	Focus of this study
1) Climate Zone	• Severe Cold • Cold • Temperate • Hot summer cold winter • Hot summer warm winter	• Cold • Hot summer cold winter
2) Living area	• Rural • Urban	• Urban
3) Life cycle of buildings	• Manufacturing of building materials and components (embodied energy) • Transporting materials from production plants to building site • Constructing buildings • Running the buildings in operation phase • Demolition of the building and recycling their parts	• Running the buildings in operation phase

Category		Possible units of analysis	Focus of this study
4) Building type	Age	• New buildings • Existing buildings	• New buildings • Existing buildings
	Utiliza-tion	• Commercial • Public • Residential	• Residential
5) Operation energy use		• Heating • Cooling • Hot water • Cooking • Lighting • Electric appliances	• Heating • Cooling

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